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CONDITIONED DISCRIMINATION AS
A FUNCTION OF TWO TYPES OF
RESPONSE DIFFERENTIATION

by

Elaine P. Burgess

A Thesis

Presented to

The Graduate Division Approved by Committee:

Drake University

Edith C. Westhof
Chairman

In Partial Fulfillment

of the Requirements for

Master of Arts in Psychology

by

Elaine P. Burgess

Earle L. Canfield
Dean of the Graduate Division

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The systematic development of a conditioned discrimination is an experimental paradigm which may be used to investigate the way in which behavior may become contingent on initially neutral stimuli. The experimental conditioning of a discrimination requires the organism to differentiate between two or more stimuli by performing different responses to each stimulus. This is usually done by making a reward contingent on a response to be performed only in the presence of an arbitrarily designated correct stimulus.

Two methods have been used to establish such discriminations: one requires of the subject two or more different but well defined responses, each of which is signaled by a different stimulus; the other method requires of the subject one response, the performance of which is signaled by one stimulus while non-performance is signaled by another stimulus. Thus in the first method the subject has a correct (rewarded) response to make under all stimulus conditions, while in the second method the subject can make only one correct response which is

rewarded if, and only if, it occurs in the presence of a unique stimulus condition.

CHAPTER I

INTRODUCTION AND PROBLEM

Two questions arise in the study of these two methods of conditioning a discrimination: (1) Is the acquisition of a discrimination between stimulus conditions facilitated when different responses are required?

I. INTRODUCTION

The systematic development of a conditioned discrimination is an experimental paradigm which may be used to investigate the way in which behavior may become contingent on initially neutral stimuli. The experimental conditioning of a discrimination requires the organism to differentiate between two or more stimuli by performing different responses to each stimulus. This is usually done by making a reward contingent on a response to be performed only in the presence of an arbitrarily designated correct stimulus.

II. STATEMENT OF PROBLEM

Two methods have been used to establish such discriminations: one requires of the subject two or more different but well defined responses, each of which is signaled by a different stimulus; the other method requires of the subject one response, the performance of which is signaled by one stimulus while non-performance

III. IMPORTANCE OF THE STUDY

is signaled by another stimulus. Thus in the first method the subject has a correct (rewarded) response to make under all stimulus conditions, while in the second method the subject can make only one correct response which is contingent between stimuli. One of the controversies which

rewarded if, and only if, it occurs in the presence of a unique stimulus condition. Two questions arise in regard to these two methods of conditioning a discrimination: (1) Is the acquisition of a discrimination between stimulus conditions facilitated when different correct responses are contingent upon the stimuli to be discriminated, or when only one response is contingent upon one stimulus, and its absence required in the presence of the other stimulus? (2) Is a discrimination between stimulus conditions more stable and more precisely defined when different correct responses are contingent upon the stimuli to be discriminated, or when only one response is contingent upon one stimulus, and its absence is required in the presence of the other stimulus?

II. STATEMENT OF PROBLEM

It is to respond appropriately according to the stimulus present. It was the purpose of this study to compare the two training paradigms commonly used in conditioning a discrimination with respect to the rate of acquisition and the stability of the resulting discrimination.

III. IMPORTANCE OF THE STUDY

Investigations of the processes by which conditioned discriminations develop seek to determine the specific conditions which account for learned differentiation between stimuli. One of the controversies which

has arisen is whether the absolute properties of the stimuli are central to this process, or whether the relational properties of the stimuli are central to the process. It has been argued that in simultaneous discriminations conditions are optimal for the formation of a discrimination based upon the relative properties of the stimuli, and that in the successive discrimination conditions are optimal for the formation of a discrimination based upon the absolute properties of the stimuli. A discrimination conditioned by the simultaneous method calls for presentation of both of a pair of different stimuli on each trial; the animal's task is to choose between these stimuli and respond accordingly. A discrimination conditioned by the successive method calls for presentation of only one stimulus on each trial: the animal's task in this case is to respond appropriately according to the stimulus and present on each particular trial.¹ Above was of the SD₁, SD₂ type; Comparison of discriminations formed by the simultaneous and successive methods of stimulus presentation have produced equivocal results. Bitterman and Wodinsky² found the successive problem to be easier,

²K. W. Spence, "The Nature of the Response in Discrimination Learning," *Psychological Review*, LIX (1952), 19-93.

¹Gregory A. Kimble (revisor), Hilgard and Marquis' *Conditioning and Learning* (second edition) (New York: Appleton-Century-Crofts, Inc., 1961), 363-364, 374-375.

supporting the absolute theory.¹ Spence found the simultaneous problem to be easier, supporting the relational theory,² and Grice found no difference.³ For the purposes of these and other investigations the discrimination training has taken one of the forms described above, specifically: (1) The S_{D1} , S_{D2} (discriminative stimulus 1 and 2) paradigm in which both stimuli are positive (response to the stimulus is reinforced) with one response being conditioned to one stimulus, and another response being conditioned to the other stimulus; (2) The S_D , S_{Δ} paradigm in which only the stimulus to which the response is being conditioned is positive, whereas the absence of that response is required during the presence of the other, or negative (non-reinforced) stimulus. The discrimination training done by Bitterman and Wodinsky in the experiments cited above was of the S_{D1} , S_{D2} type; rats in mazes and on Lashley jumping stands were

might be an extinction curve. He also suggested concerted

¹M.E. Bitterman and Jerome Wodinsky, "Simultaneous and Successive Discrimination," Psychological Review, LX (1953), 371-376.

²K.W. Spence, "The Nature of the Response in Discrimination Learning," Psychological Review, LIX (1952), 89-93.

³G.R. Grice, "Visual Discrimination Learning with Simultaneous and Successive Presentation of Stimuli," Journal of Comparative Physiological Psychology, XLII (1949), 365-373.

required to respond right or left, depending upon the stimulus presented. Spence also used this training paradigm. He outlined the successive problem as one in which only one cue was present on each trial; the animal went right if both alleys were black and went left if both alleys were white. The animals in these two studies therefore had a correct response to make for all stimulus conditions. Grice, on the other hand trained animals to discriminate differently sized circles on doors which opened into reward chambers containing reinforcement for the "positive" circle and no reinforcement for the "negative" circle, an S_D , S_{Δ} paradigm. Grice recorded response latencies; the resulting curves indicated changes in response strength--smaller latencies to the positive stimulus and greater latencies to the negative stimulus. This finding led Grice to propose that latency to the positive stimulus might be a learning curve whereas latency to the negative stimulus might be an extinction curve. He also suggested concerted investigation of the role of inhibitory processes occurring during formulation of conditioned discriminations. Lawrence also pointed to the possibility that the

inhibitory process might be of central importance in the formation of conditioned discriminations.¹ Adapting the

¹Kimble, op. cit., pp. 364, 379.
²Harley M. Hanson, "Effects of Discrimination Training on Stimulus Generalization," *Journal of Experimental Psychology*, 41 (1953), 1-11.
³D.H. Lawrence, "The Transfer of Discrimination Along a Continuum," *Journal of Comparative Physiological Psychology*, VL (1952), 465-471.

maze situation to an S_D , S_{delta} paradigm for the purpose of studying transfer along a brightness continuum, Lawrence found that although the generalization of secondary reinforcement and conditioned inhibition were equally important as variables which affect the rate of learning during acquisition, the role of conditioned inhibition proved to be more influential in the subsequent learning of a reversal problem.

Attempting to explain transposition, the transfer of a discrimination to new pairs of stimuli, Spence developed theoretical generalization gradients for excitation and inhibition, which have been called post-discrimination gradients.¹ Recent experimental efforts have undertaken the examination of actual post-discrimination gradients with respect to the effects of extinction to a negative stimulus (conditioned inhibition) upon discrimination. These studies have employed the S_D , S_{delta} paradigm for the discrimination training.

An investigation by Hanson determined that showed generalization curves which result from discrimination training are not comparable to ordinary generalization curves.² He found post-discrimination generalization

¹Kimble, op. cit., pp. 364, 379.

²Harley M. Hanson, "Effects of Discrimination Training on Stimulus Generalization," Journal of Experimental Psychology, LVIII (1959), 321-334.

gradients to be steeper than anticipated and to be displaced away from the negative stimulus in the direction of the positive stimulus. This displacement was not incorporated into Spence's model. possible for the animal to respond. Honig's findings, in a later investigation of the prediction of differential responding, generally support the possibility that extinction to the negative stimulus is, more influential in a conditioned discrimination than used acquisition to the positive stimulus.¹ Using the S_D , S_{Δ} paradigm to condition simultaneous and successive discriminations for the purpose of comparison, he found that the post-discrimination gradient which resulted from the successive discrimination produced a peak shift. This shift seemed to depend on extinction to the negative stimulus, and again was not anticipated by Spence. Post-g. discrimination gradients resulting from the simultaneous discrimination produced no peak shift. When the simultaneous and successive problems were reversed, the animals which were trained on the successive problem first showed transposition, while those trained on the simultaneous problem first did not. Honig concluded that the simultaneous presentation did not result in extinction to the post-discrimination gradients using the S_D , S_{Δ} training

¹W.K. Honig, "Prediction of Preference, Transposition and Transposition Reversal from the Generalization Gradient," Journal of Experimental Psychology, LXIV (1962), 239-248. ²Kimble, op. cit., p. 375.

negative stimulus because of its concomitant presence with the positive, reinforced stimulus. The successive presentation resulted in extinction to the negative stimulus, however, since it was not possible for the animal to respond, and be reinforced, in the presence of the negative stimulus. A footnote in Honig's article described the typical operant S_D , S_{Δ} training he used in the study, and emphasized that this paradigm differed from that used by Bitterman and by Spence. Kimble also calls attention to this discrepancy.¹

Conflicting data from some of the discrimination studies, plus recent findings related to the negative stimulus in a discrimination lead to the question whether the two commonly used training paradigms, S_D , S_{Δ} and S_{D1} , S_{D2} , result in comparable discrimination conditioning. If extinction of the response to the negative stimulus is of greater importance to the discrimination than is acquisition of the response to the positive stimulus, then it is quite possible that the two training paradigms may differ with regard to what is learned. Should it be the case that performances of the discrimination differ significantly, then conclusions drawn from studies of post-discrimination gradients using the S_D , S_{Δ} training procedure may not apply to post-discrimination gradients

¹Kimble, op. cit., p. 375.

which result from discriminations conditioned with two positive stimuli, the S_{D1} , S_{D2} training procedure. In

CHAPTER II

EXPERIMENTAL METHODOLOGY
1. GENERAL PROCEDURE
addition, it is possible that conflicting results from investigations which were designed to probe the "absolute versus relative" controversy may be confounded by differences in these training procedures.

two paradigms of conditioning. The present study is designed to compare acquisition and extinction measures occurring as a function of these two forms of discrimination training. If extinction

to the negative stimulus is of central importance to the

Group I: S_D , S_{Δ} paradigm. Each animal was discrimination problem, as Honig's evidence suggests, required to (a) peck one of two keys in the presence of, significant differences in acquisition and extinction and only in the presence of, the stimulus color designated measures would be expected to result.

positive for that bird, and (b) not peck either of the two

Experimental methodology is presented in Chapter pecking keys in the presence of the other stimulus color II of the thesis, and includes an outline of procedure, designated negative. This constituted an S_D , S_{Δ} paradigm since only one correct response is required in the apparatus, the specific procedure used, and the resulting presence of one stimulus, and the absence of that response data with its statistical treatment. Chapter III deals with findings and conclusions. A summary of the thesis response differentiation is therefore one of "response, may be found in Chapter IV.

no response." Presentations of a red or green stimulus

light were made according to the successive method; that is, one color was presented through a single aperture on each successive trial.

Group 11: SD₁, SD₂ paradigm. Each animal was re-

CHAPTER II

quired to (a) peck one of two keys in the presence of one stimulus color, EXPERIMENTAL METHODOLOGY key in the presence of the other stimulus color. This constituted an SD₁, SD₂

I. GENERAL PROCEDURE

paradigm since there is a correct response which is required. For purposes of comparing two paradigms of conditioning a discrimination, two groups of subjects consisting of eight pigeons each were trained to discriminate between a red and a green light. "Response to left key." Stimulus

presentations were made according to the successive method as described above.

Group I: SD, S_{delta} paradigm. Each animal was required to (a) peck one of two keys in the presence of, and only in the presence of, the stimulus color designated positive for that bird, and (b) not peck either of the two pecking keys in the presence of the other stimulus color designated negative. This constituted an SD, S_{delta} para-

digm since only one correct response is required in the presence of one stimulus, and the absence of that response according to suggestions by Ferster.¹ Two 2-inch-square is required in the presence of the other stimulus. The plexiglass pecking keys were installed on one wall 7 1/2 inches from the floor of the box, and 4 inches apart on response differentiation is therefore one of "response, no response." Presentations of a red or green stimulus center. The left key (Key 1) was vertically striped, and light were made according to the successive method; that the right key (Key 2) was horizontally striped. Both is, one color was presented through a single aperture on each successive trial.

¹C.B. Ferster, "The Use of the Free Operant in Analysis of Behavior," Psychological Bulletin, 51 (1953), 263-270.

Group II: S_{D1}, S_{D2} paradigm. Each animal was required to (a) peck one of two keys in the presence of one stimulus color, and (b) peck the other key in the presence of the other stimulus color. This constituted an S_{D1}, S_{D2} paradigm since there is a correct response which is required in the presence of one stimulus and another correct response required in the presence of the other stimulus. The response differentiation in this case was one of "response to right key", "response to left key." Stimulus presentations were made according to the successive method as described above.

Subjects. From a population of sixteen experimentally naive pigeons, eight were randomly assigned to each of the two conditioning paradigms, which were designated: Group I, S_D, S_{delta}; Group II, S_{D1}, S_{D2}.

Apparatus. A modified Skinner box was constructed according to suggestions by Ferster.¹ Two 2-inch-square plexiglass pecking keys were installed on one wall 7½ inches from the floor of the box, and 4 inches apart on center. The left key (Key 1) was vertically striped, and the right key (Key 2) was horizontally striped. Both

¹C.B. Ferster, "The Use of the Free Operant in Analysis of Behavior," Psychological Bulletin, L (1953), 263-270.

keys were illuminated with white light during all performance intervals. The red or green stimulus was presented through a single aperture located $2\frac{1}{2}$ inches on center above the two pecking keys. Contact switches located on the back of each key activated digital counters each time the key was pecked.

Situated directly below the pecking keys was a feeder cup which when raised into feeding position allowed the animal to feed for a fixed period of time. Feeding time was determined by a condenser discharge delay circuit which activated the solenoid which delivered the reinforcement. A foam rubber block was placed in the feeder cup during extinction trials making primary reinforcement unavailable. (See Figure 1, page 13.)

II. SPECIFIC PROCEDURAL CONDITIONS AND CONTROLS

Acquisition. All animals were reduced to eighty percent of their ad lib weight and maintained on a twenty-four-hour deprivation schedule during the experiment. When the animals reached the desired weight they were familiarized with the apparatus, the feeder, feeder activation, and trained to peck the keys in the manner described by Ferster.¹ All animals were trained to peck

¹Ferster, op. cit., pp. 271-274.

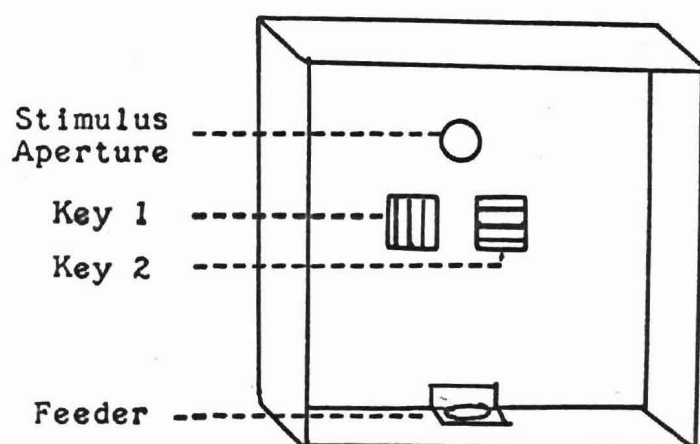


Figure 1. Diagram of Apparatus

both pecking keys until they switched keys with facility and until each animal had obtained the same number of reinforcements to each key. Discrimination conditioning began on the following day. A quarter ounce of grain was obtained daily by each animal as reinforcement. Each animal was given one block of trials daily until the criterion was reached. A block of trials consisted of twelve 4-minute intervals during which either the red or green stimulus light was presented, and a 1-minute dark interval between each 4-minute stimulus

presentation. Stimuli were presented in the successive manner; that is, only one color was present during each 4-minute interval. Presentations of red and green stimuli were randomized within a block of twelve performance intervals in such a way that each color was presented an equal number of times (six each), and the same color was not presented for more than two consecutive 4-minute intervals. Three randomized series of presentations were counterbalanced for initial color and key preference, used for all animals.

All animals were reinforced on a variable-interval schedule with an average interval of 45 seconds. Owing to the fact that the S_D , S_{Δ} paradigm called for reinforcement for only one of the stimuli, while the S_{D1} , S_{D2} paradigm called for reinforcement for both stimuli, the total amount of eating time per block of trials was equated.

Therefore, the feeder remained in place for a duration of 4 seconds for Group I (S_D , S_{delta}) and for a duration of 2 seconds for Group II (S_{D1} , S_{D2}).

Animals were removed from their home cages by the experimenter and placed in the darkened Skinner box to begin one day's block of trials. The stimulus aperture and pecking keys were illuminated at once. Following the twelve randomized conditions, the animal was removed from the box and replaced in its home cage where water and grit were available.

Group II (S_{D1} , S_{D2}). Four animals in this group were assigned to Group I, S_D , S_{delta} . The red stimulus was designated positive (S_D) for four animals in this group, and green was designated negative (S_{delta}); the remaining four animals were assigned green as the positive stimulus and red as the negative stimulus. Key 1 was designated as the positive key for half the group while Key 2 was designated as the positive key for the other half. This procedure counterbalanced for initial color and key preference.

The problem for an animal in this group who had been assigned the red light as positive and Key 1 as positive, was as follows: When the red light came on he was required to peck Key 1, and to not peck Key 2. Reinforcement lasting 4 seconds was given five times for correct responses to Key 1. At the end of the 4-minute red interval the apparatus and all lights were turned off

for 1 minute. If the next interval were green, the animal was required not to peck either Key 1 (or Key 2, for red) during Thus animals in Group I had but one correct response possibility, the pecking of the positive key during the S_D (positive stimulus) interval. Three incorrect responses were possible: pecking the negative key during the S_D (positive) stimulus interval; pecking the positive key during the S_{Δ} (negative) interval; pecking the negative key during the S_{Δ} (negative) interval. The experimental procedures described allowed the following data to be collected: Group II (S_{D1} , S_{D2}). Four animals in this group were assigned Key 1 as the designated correct key for the red stimulus, and Key 2 as the designated correct key for the green stimulus. The reverse was true for the remaining four animals. The problem for an animal in this group who had been assigned Key 1 as the correct key for the red light and Key 2 as the correct key for the green light was as follows: When the red light came on he was required to peck Key 1 and not to peck Key 2. Reinforcement lasting 2 seconds was given five times for correct response to Key 1. At the end of the 4-minute red interval the apparatus and all lights were turned off for 1 minute. If the next interval were green, five reinforcements of 2 seconds each were given for pecks to Key 2.

response. Thus animals in Group I had two correct response possibilities: the pecking of Key 1 (positive for red) during the S_{D1} (red) stimulus interval, and the pecking of Key 2 (positive for green) during the S_{D2} (green) stimulus interval. Two incorrect responses were possible: the pecking of Key 2 during S_{D1} (red) stimulus interval, and the pecking of Key 1 during S_{D2} (green) stimulus interval.

Definition and measurement of learning. The experimental procedures described allowed the following data to be collected:

Group I: (1) number of correct responses to the frequency of correct responses becomes significantly greater than the frequency of incorrect responses. Tests of the significance of the difference between correct and incorrect responses to the positive key during S_{Δ} intervals, (3) number of incorrect responses to the unassigned key during S_D intervals, and (4) number of incorrect responses to the unassigned key during S_{Δ} intervals. The following shows the way in which this may be diagrammed:

One block of trials was defined as one day's presentations of twelve stimulus intervals, and daily distributions of correct and incorrect responses over the last six trial blocks may be tested for significance by means of a non-parametric statistic. Therefore, the discrimination was considered to be conditioned when the differences between distributions of correct and error responses occurring during the last six days' trials were significant at the .01 level.

Group II: (1) number of correct responses to the designated positive key for S_{D1} (2) number of incorrect responses occurring during the last six days' trials were significant at the .01 level.

responses to the opposing key, (3) number of correct responses to the designated positive key for S_{D2} , and (4) the number of incorrect responses to the opposing key. The following shows the way in which this may be diagrammed:

S_{D1}	S_{D2}
Correct--Key 1	Correct--Key 2
Incorrect--Key 2	Incorrect--Key 1

Since both groups yield data in which the possibility of a correct and incorrect response occurs, the learned discrimination may be said to be defined when the frequency of correct responses becomes significantly greater than the frequency of incorrect responses. Tests of the significance of the difference between correct and error responses were made daily for each animal beginning on the sixth day. Each day cumulative correct and incorrect responses were computed for the last six consecutive days. One block of trials was defined as one day's presentations of twelve stimulus intervals, and daily distributions of correct and incorrect responses over the last six trial blocks may be tested for significance by means of a non-parametric statistic. Therefore, the discrimination was considered to be conditioned when the differences between distributions of correct and error responses occurring during the last six days' trials were significant at the .01 level.

Extinction. When statistical significance defined the discrimination for the last six days' trials, extinction trials were begun with the next day's trial. Extinction trials replicated acquisition trials as closely as possible, according to suggestions by Skinner.¹ A foam rubber block was placed in the feeder cup rendering primary reinforcement unavailable. When correct responses were made the apparatus was activated in the same manner as during acquisition trials. The feeder and feeder light along with other possible secondary reinforcers were therefore present. After each day's extinction trial was completed, the animal was returned to his home cage. An hour later the animal was fed his daily ration of a quarter ounce of grain in that cage.

Extinction trials continued until no response to either key was emitted for one full block of twelve stimulus intervals.

III. RESULTS

Acquisition. Acquisition of the conditioned discrimination was defined as the significant increase of correct responses and decrease of error responses as a function of time (trials). The establishment of the

¹Skinner, B.F., "Are Theories of Learning Necessary?," Psychological Review, LVII (1950), 204.

discrimination acquisition was statistically determined for each animal by making a comparison with the Kruskal-Wallis H statistic of the distributions of correct and error responses for the last six successive days' trials.¹ When these two distributions could be assumed to come from different populations at the .01 level of confidence, discrimination acquisition was considered to be established. Each animal's learning curve for discrimination acquisition may be found in Appendix A.

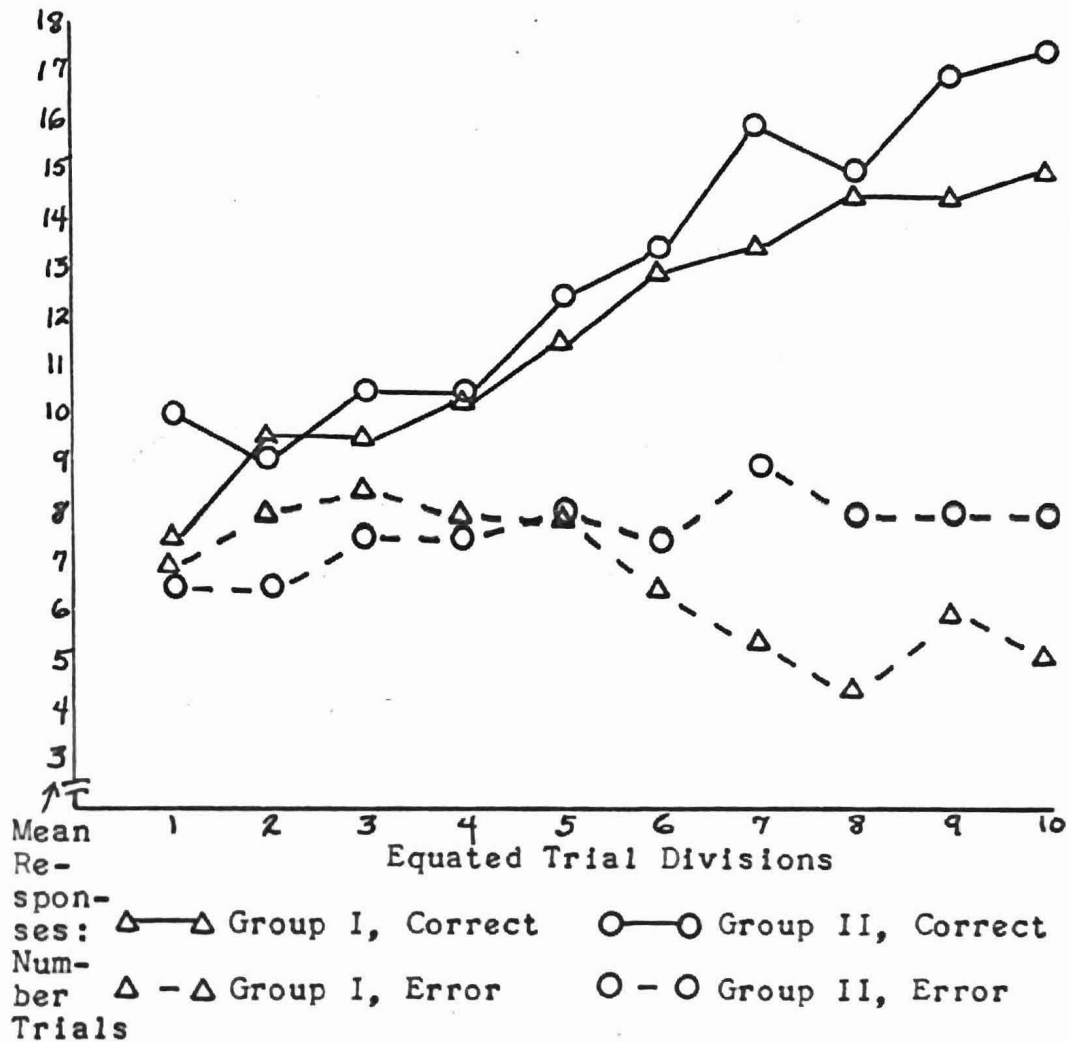
A modified Vincent's curve² in Figure 2 shows the increase of correct responses and decrease of error responses for Group I and II plotted as a function of equated trials.³

The mean number of trials to acquisition was 8.5 for Group I and 16.75 for Group II. Testing with the

¹Sidney Siegel, Nonparametric Statistics, (New York: McGraw Hill, 1956), pp. 184-193.

²Kimble, op. cit., p. 114.

³Vincent's curves equating trials were derived by dividing total correct and error responses of each animal into ten segments. The mean number of correct and error responses in each segment for the eight animals in each group was then computed. Modification was necessary in order to render the curves comparable, and was done in the following manner: the mean number of trials in each one-tenth segment (.85 for Group I, 1.68 for Group II) was divided into the mean number of correct and of error responses for that segment.



Ratio of mean correct and error responses to
mean number of trials in 10 successive
trial divisions.

\bar{X} trials in each $1/10 = .85$, Group I

\bar{X} trials in each $1/10 = 1.68$, Group II

Figure 2. Group learning curves of a discrimination conditioned by two different paradigms.

Mann-Whitney U¹ statistic to determine whether the two distributions of acquisition trials came from different populations, resulted in a U of 3, which is significant at the .002 level of confidence.²

Extinction. Extinction of the conditioned discrimination is defined as the degeneration of total response frequency along with decrease in correct response and increase in error response as a function of time (trials). Extinction trials ceased when no response was made for one full day's trial. Individual extinction curves may be found in Appendix B.

Figure 3 shows a Vincent's curve adapted for extinction on which degeneration of total response for Group I and II is shown as well as the decrease of correct response and increase of error response plotted as a function of equated trials.³

The mean number of trials to extinction of the discrimination was 6.615 for Group I and 5.75 for Group II. A Mann-Whitney U, testing whether the two distributions of number of trials to extinction were from

¹Siegel, op. cit., pp. 116-127.

²See Appendix C.

³Modification used for the Vincent's learning curve was unnecessary for the extinction curve since the mean number of trials per one-tenth segment did not differ significantly between the two groups. Data was therefore comparable without this transformation.

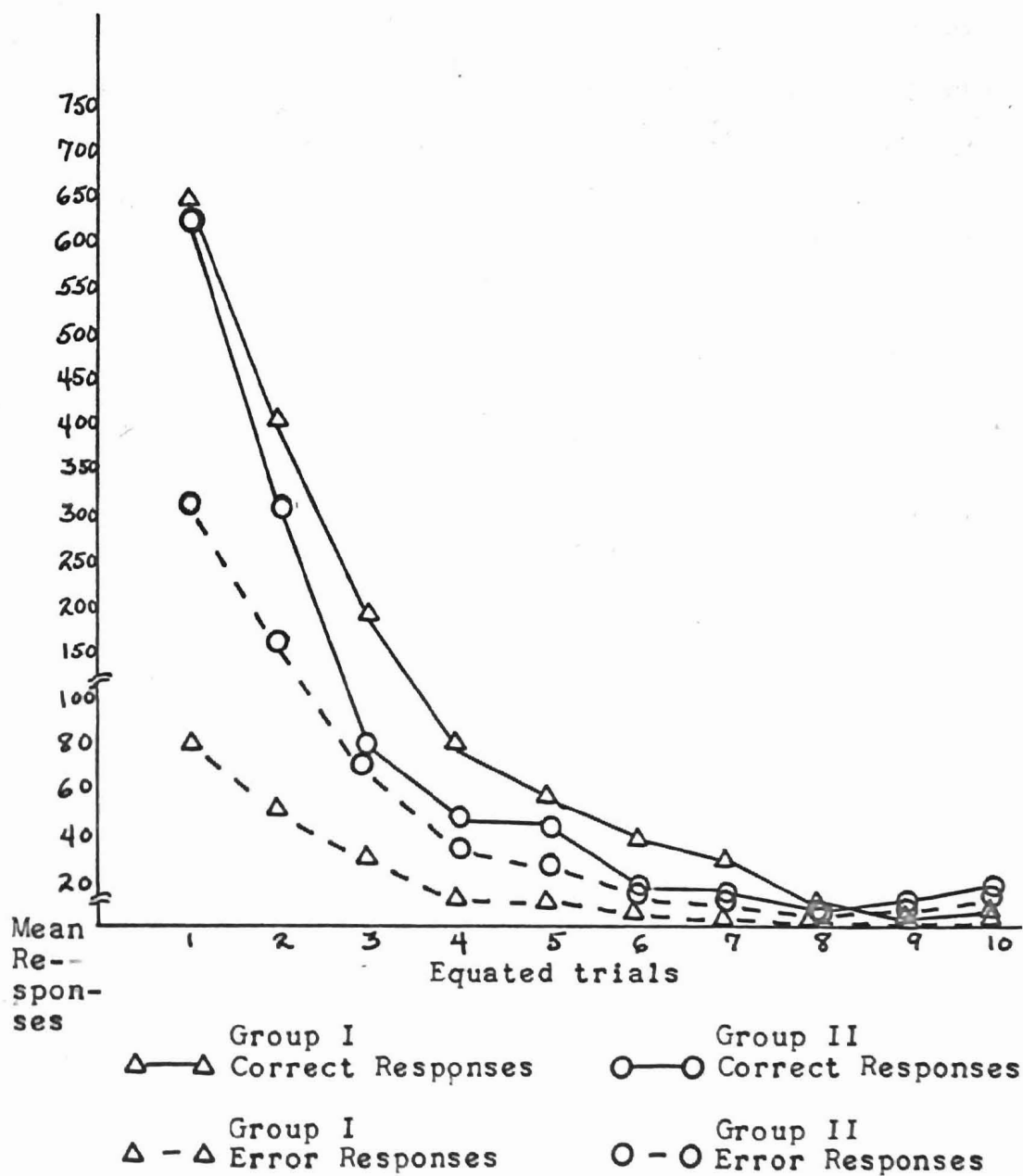


Figure 3. Group extinction curves of a discrimination conditioned by two different paradigms.

different populations, was 26, which does not approach significance.¹ The U of 26 was converted to a Z score of .630 for comparison with a Z score which corrects for ties. Since the corrected Z score was .641, the difference between corrected and uncorrected Z score transformation was negligible. (Both Z scores have a probability of .528 in a two tailed test.) U of 7 was significant at

the .006 level. Inspection of the modified Vincent's learning curve (Figure 2) for acquisition of the discrimination shows a greater number of total responses for Group II than for Group I. It would be assumed that during extinction a greater number of responses were therefore available in Group II for extinction than in Group I. In addition, the acquisition rate for the two groups differed significantly but the extinction rate did not. For these two reasons a more sensitive measure of difference between the two groups' resistance to extinction was made by comparing distributions of individual proportional differences between correct and error responses. All correct and error responses made during extinction trials were converted to proportion of correct responses to total responses, and proportion of error responses to total responses for each animal. The

¹See Appendix C.

difference between these proportional correct and error responses was then determined for each animal. The mean difference between proportional correct and error responses for Group I was .675, and for Group II was .3425. When used to condition a discrimination was initially concerned with whether such a discrimination might be facilitated differences were from different populations, the Mann-Whitney U determined that a U of 7 was significant at the .006 level.¹

The comparison of two training paradigms commonly used to test whether these distributions of proportional differences were from different populations, the Mann-Whitney U determined that a U of 7 was significant at the .006 level.¹ reinforcement was contingent upon response to one positive stimulus and the absence of that response was required to the negative stimulus. Secondly, the comparison was concerned with whether either of these conditioning methods, the S_D , S_{Δ} or the S_{D1} , S_{D2} , conditioned a more stable or better defined discrimination.

1. ACQUISITION

The present study has demonstrated that the S_D , S_{Δ} paradigm significantly facilitated the conditioning of the discrimination when the measure of that facilitation is rate of acquisition. The range of acquisition trials required by the S_D , S_{Δ} group (Group I) was from 6 to 15 trials, with a mean of 8.5 trials. The S_{D1} , S_{D2} group (Group II) evidenced a range of from 10 to 32 acquisition trials with a mean of 16.75 trials.

~~Extinction theorists might have predicted such an outcome~~ ¹See Appendix C. operationally the S_{D1} , S_{D2}

discrimination problem CHAPTER III more than a doubled S_D .

S_{Δ} problem.² For example, S_{D1} may call for reinforcement (conditioning) to Key 1, and no reinforcement (extinction) to Key 2. S_{D2} , then, calls for reinforcement (conditioning) to Key 2, and no reinforcement (extinction) to Key 1. The S_D , S_{Δ} paradigm would consist of half the problem since it requires reinforcement (conditioning) to only one stimulus and no reinforcement (extinction) to the other stimulus.

DISCUSSION

The comparison of two training paradigms commonly used to condition a discrimination was initially concerned with whether such a discrimination might be facilitated when reinforcement was contingent upon the differentiation of the response to two positive stimuli or when the reinforcement was contingent upon response to one positive stimulus and the absence of that response was required to the negative stimulus. Secondly, the comparison was concerned with whether either of these conditioning methods, the S_D , S_{Δ} or the S_{D1} , S_{D2} , conditioned a more stable or better defined discrimination.

Inspection of the learning curve for acquisition of the discrimination in Figure 2 reveals that the discrimination acquisition was established in a different manner by each group. The S_{D1} , S_{D2} group defined the discrimination by an increase in the frequency of correct responses, while the S_D , S_{Δ} group responses remained essentially the same.

I. ACQUISITION

The present study has demonstrated that the S_D , S_{Δ} paradigm significantly facilitated the conditioning of the discrimination when the measure of that facilitation is rate of acquisition. The range of acquisition trials required by the S_D , S_{Δ} group (Group I) was from 6 to 15 trials, with a mean of 8.5 trials. The S_{D1} , S_{D2} group (Group II) evidenced a range of from 10 to 32 acquisition trials with a mean of 16.75 trials.

Extinction theorists might have predicted such an outcome by proposing that operationally the S_{D1} , S_{D2}

discrimination problem is nothing more than a doubled S_D , S_{Δ} problem.¹ For example, S_{D1} may call for reinforcement (conditioning) to Key 1, and no reinforcement (extinction) to Key 2. S_{D2} , then, calls for reinforcement (conditioning) to Key 2, and no reinforcement (extinction) to Key 1. The S_D , S_{Δ} paradigm would consist of half the problem since it requires reinforcement (conditioning) to only one stimulus and no reinforcement (extinction) to the other stimulus.

Inspection of the learning curve for acquisition required for the subject to finally make no response while in of the discrimination in Figure 2 reveals that the distribution of the number of extinction trials required by both groups has been shown in a different manner by each group. The S_{D1} , S_{D2} group defined the discrimination by an increase in the frequency of correct responses, while the frequency of error responses remained essentially the same. The S_D , S_{Δ} group, however, defined the discrimination by an increase in the frequency of either training paradigm since it is quite probable that of correct responses as well as a decrease in the frequency of error responses.

The discrimination to be made was essentially the same for both groups, each being trained to differentiate between two conditions (presence of red or green stimulus by the requirement that only one stimulus be reinforced,

received reinforcement on only half the trial intervals.

¹Gregory A. Kimble, (revisor), Hilgard and Marquis' Conditioning and Learning, second edition (New York: Appleton-Century-Crofts, Inc.), p. 364.
The Macmillan Company, 1960), p. 188.

lights).¹ The definition of the discrimination in terms of the statistical significance between distributions of correct and error responses for six consecutive days' trials allowed all animals substantially the same number of trials (six) in which the discrimination was actually being performed.

II. EXTINCTION

One of the measurements of resistance to extinction which has frequently been used is the number of trials required for the subject to finally make no response while in the stimulus situation. The distributions of the number of extinction trials required by both groups has been shown statistically to be drawn from the same population, so it would appear that resistance to extinction of the conditioned discrimination was the same for both groups. This may not have resulted, however, from intrinsic properties of either training paradigm since it is quite probable that the measure of resistance to extinction was confounded by at least two variables.

Reinforcement was received on every trial interval for the S_{D1} , S_{D2} group while the S_D , S_{delta} group, bound by the requirement that only one stimulus be reinforced, received reinforcement on only half the trial intervals.

¹Kimble, op. cit., pp. 290, 301. ²Ibid., p. 113.

¹Reed Lawson, Learning and Behavior, (New York: The Macmillan Company, 1960), p. 188.

It has been shown that this "varied" reinforcement, experienced by the S_D , S_{Δ} group, produces greater resistance to extinction than "regular" (every trial) reinforcement.¹ It may be the case that this variable, inherent to the nature of the difference between the two paradigms, has offset the probability that the greater number of trials to reach criterion required by the S_{D1} , S_{D2} group would produce greater resistance to extinction for that group.²

Because resistance to extinction has not often been used as a measure of conditioning,³ and because it proved to be either insensitive or unreliable (or both) to differences between the S_{D1} , S_{D2} and the S_D , S_{Δ} methods of conditioning, closer scrutiny of the responses emitted during both acquisition and extinction was indicated.

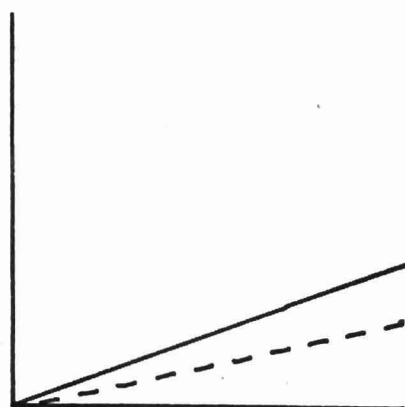
Previous studies have shown that the number of reinforcements awarded during training increases the number of responses during extinction.⁴ Recorded correct and error responses were therefore converted into proportions of total responses so that the data might be comparable in spite of the higher frequency of responses to which the animal has been able to "define" the discrimination.

¹Kimble, *op. cit.*, pp. 290, 301. ²*Ibid.*, p. 113.

³*Ibid.* ⁴*Ibid.*, p. 111.

made by the S_{D1} , S_{D2} group because of their greater number of reinforcements. Figure 4 illustrates such a conversion for one animal, B-3, from Group I. It will be noted that the difference between proportional correct and error responses, which is to be compared between groups, in effect constitutes a measure of the magnitude of difference between correct and error responses after proportional conversion.

If resistance to extinction were a reliable and sensitive measure of the discrimination acquisition, then it might be supposed that on the basis of evidence previously cited (page 27) that no significant difference would be found to exist between proportional correct and error responses during extinction. However, examination of the data shows that distributions for each group of differences between proportional correct and error responses during extinction could be expected to come from different populations at the .006 level of confidence! The S_D , S_{delta} group evidenced significantly greater magnitude of difference between the proportional correct and error responses than did the S_{D1} , S_{D2} group. If it can be inferred that this difference describes the degree to which the animal has been able to "define" the discrimination, then it is evident that the S_D , S_{delta} paradigm actuated a more clearcut "definition" of the discrimination than did the S_{D1} , S_{D2} paradigm.

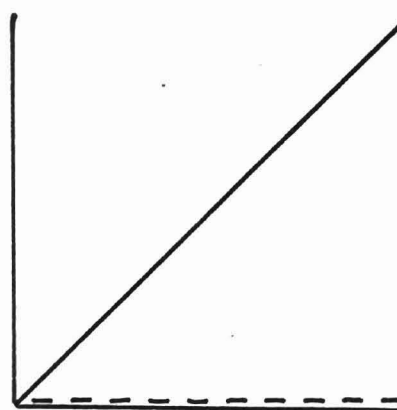


Animal - B-3
Group I

6 Discrimination
Trials

Correct
Responses

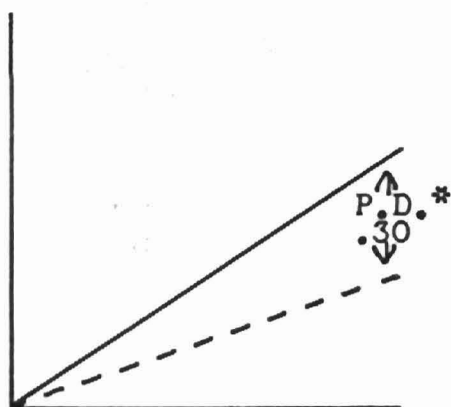
Error
Responses



Animal - B-3
Group I

Extinction
Trials

Total Recorded
Responses

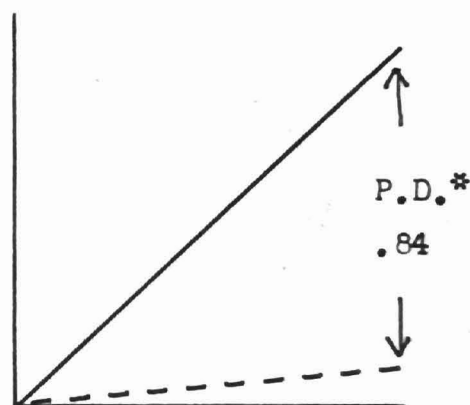


Animal - B-3
Group I

6 Discrimination
Trials

Correct
Responses

Error
Responses



Animal - B-3
Group I

Extinction
Trials

Proportional Responses

*Proportional Difference

Figure 4. Comparison of Recorded and Proportional responses for an animal in one discrimination conditioning paradigm.

Any attempt to explain the disparity between extinction measures of proportional correct and error response differences between the two groups must take stimulus generalization into account. The two stimuli (red and green lights) undergoing discrimination in this study were alike for both groups in all respects except one. For the S_{D1} , S_{D2} group each of the two stimuli had reinforcing properties; for the S_D , S_{Δ} group only one of the stimuli had reinforcing properties. Stimulus generalization is expected to occur from one stimulus to another to the degree that the stimuli are perceived as similar.¹ According to this proposal, stimulus generalization would be greater between stimuli for the S_{D1} , S_{D2} paradigm, and would account for the narrower "definition" of the discrimination made by the S_{D1} , S_{D2} group.

Inspection of differences between proportional correct and error responses for the S_{D1} , S_{D2} group during the last six acquisition trials (when the discrimination was actually being performed as shown statistically), along with those obtained during extinction, showed that in all but one case the magnitude of this difference was greater during the six "discriminating" trials than during acquisition as opposed to those made during extinction. Numerous studies report descriptions of generalization gradients and post-discrimination gradients, along with S_{Δ} group revealed the opposite to be the case. For

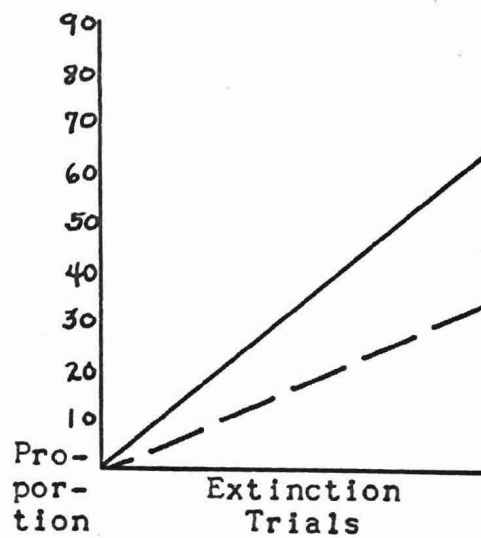
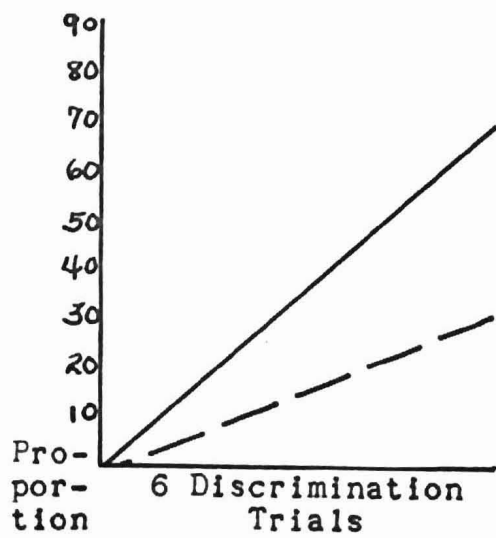
¹Kimble, op. cit., pp. 350, 369. d., pp. 365, 380

all but two cases in this group, the magnitude of difference between proportional correct and error responses was greater during extinction trials than during the last six "discriminating" trials. Means of group proportional correct and error responses may be found in Figure 5.

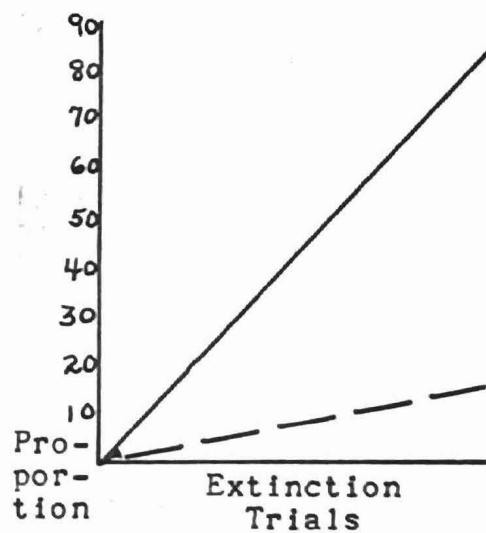
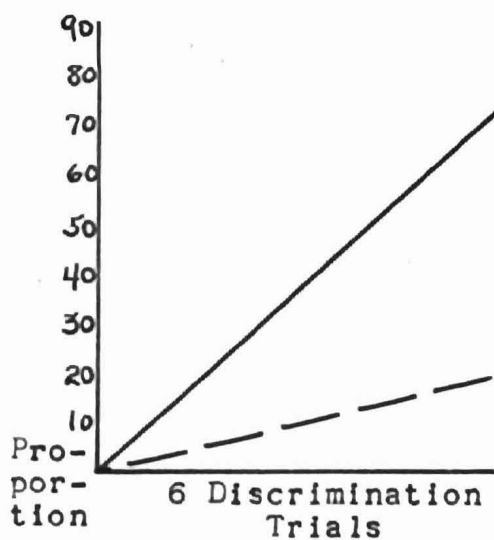
Overlapping generalization gradients of stimulus generalization can explain the decrement in difference for the S_{D1} , S_{D2} group.¹ However, such gradients do not explain the increment in the magnitude of difference for the S_D , S_{delta} group. In fact, overlapping gradients of positive and negative stimuli should serve to decrease rather than increase that difference. A "no response tendency" presumably generalizes to the positive stimulus, thereby depressing the number of correct responses. In the same manner, the "response tendency" to the positive stimulus presumably generalizes to the negative stimulus, thereby increasing the number of error responses.²

It is difficult to appraise the validity of this increment in magnitude of difference for the S_D , S_{delta} group, since related experimental evidence has not compared differences between correct and error responses made during acquisition as opposed to those made during extinction. Numerous studies report descriptions of generalization gradients and post-discrimination gradients, along

¹Kimble, op. cit., p. 349. ²Ibid., pp. 365, 380



Group II

 S_{D1} S_{D2} 

Group I

 S_D , S_{Δ}

- \bar{X} Proportional correct responses
 - - \bar{X} Proportional error responses

Figure 5. Mean proportional correct and error responses for two differing paradigms of discrimination conditioning.

with the effects of several variables such as equivalence of stimuli, stimulus intensity, and partial reinforcement.¹ Reported differences in these studies arise from either measures taken during acquisition or extinction, but not from both. It remains to be seen, therefore, whether the difference between proportional correct and error responses found in the S_D , S_{Δ} group's performance of the discrimination does indeed increase during extinction, as the present study indicates, or whether some variable intrinsic to this experiment or to this particular paradigm may be confounding the data. The need for further experimental evidence is clearly indicated.

III. CONCLUSIONS

The question whether both the S_D , S_{Δ} and the S_{D1} , S_{D2} paradigms lead to the same learning of the conditioned discrimination remains unanswered. While

some evidence cited in this thesis supports the contention that the two paradigms may lead to different learning of the same discrimination, the evidence is by no means conclusive. However, the greater number of trials to acquisition required by the S_{D1} , S_{D2} group, the difference in the manner of establishment of the discrimination, plus the increase in difference between proportional

correct and error responses from acquisition to extinction

¹W.K. Honig, "Prediction of Preference, Transposition and Reversal from the Generalization Gradient," Journal of Experimental Psychology, LXIV (1962), 239-248.

¹Ibid., pp. 281-394.

for the S_D , S_{Δ} group, lead to the conjecture that to the these paradigms could occasion quite different learning, which may not have been revealed owing to limitations of the experimental design. However, support for Honig's contention that extinction to the negative stimulus is of greater import to the discrimination than conditioning to the positive have stimulus, has been supported.¹ It may therefore be the case that it is no longer fruitful to pursue the course of comparing discriminations conditioned by simultaneous and successive stimulus presentations in an effort to resolve the controversy concerning the absolute versus relative stimulus properties as the basis for solution of a discrimination problem. The degree to which extinction can occur to a particular stimulus may be the influential circumstance which provides the basis for solution of the discrimination problem.

Evidence cited in this study clearly indicates that results, conclusions, and theoretical positions extracted from studies which employ one paradigm are not applicable to the other paradigm. The difference in number of trials to acquisition between the two groups, and the disparity of differences found to exist between correct and error

¹W.K. Honig, "Prediction of Preference, Transposition and Transposition Reversal from the Generalization Gradient," Journal of Experimental Psychology, LXIV (1962), 239-248.

responses of the two groups during extinction, lead to the conclusion that measurements taken from either conditioning paradigm are, at best, highly questionable if applied to circumstances or positions based upon the other conditioning

CHAPTER IV

A comparison of two training paradigms commonly used in the experimental conditioning of a discrimination. Until more is known about the underlying processes of these two paradigms, it must suffice that experiments be undertaken in the present study. One procedure, the S_{D1} , S_{D2} paradigm, conditions one response to one stimulus, and that they refrain from making generalizations which encompass the other paradigm. Reinforcement is contingent upon correct response to the designated appropriate stimulus; both stimuli are of these two paradigms be made for the purposes of: (1) positive, that is, reinforced. The other procedure, the S_{D1} , S_{D2} paradigm, conditions one response to one positive stimulus, but requires the absence of that response for the other stimulus. Reinforcement is contingent upon correct response to the positive stimulus; no reinforcement is given in the presence of the negative stimulus.

It would be hoped that more refined studies of each of these two paradigms be made for the purposes of: (1) positive, that is, reinforced. The other procedure, the S_{D1} , S_{D2} paradigm, conditions one response to one positive stimulus, but requires the absence of that response for the other stimulus. Reinforcement is contingent upon correct response to the positive stimulus; no reinforcement is given in the presence of the negative stimulus.

Studies of conditional discrimination which have made use of the S_{D1} , S_{D2} or the S_{D1} , S_{D2} paradigms have been remiss in not recognizing the difference between the two paradigms and in failing to consider that conclusions or generalizations drawn from one training paradigm might not be applicable to conditions and conclusions inherent in the other paradigm. An exception to this is a study by Honig in which attention is called to the particular

paradigm used.¹

CHAPTER IV

In the present study, measures of acquisition and extinction were made in order to compare directly a discrimination conditioned by the S_D , S_{Δ} paradigm to the same discrimination conditioned by the S_{D1} , S_{D2} paradigm.

A comparison of two training paradigms commonly used in the experimental conditioning of a discrimination was undertaken in the present study. One procedure, the S_{D1} , S_{D2} paradigm, conditions one response to one stimulus by each of these procedures to discriminate between a red and a green stimulus light in a modified Skinner box. The two stimuli were presented in the designated appropriate stimulus; both stimuli are successive manner; that is, one stimulus was presented positive, that is, reinforced. The other procedure, the S_D , S_{Δ} paradigm, conditions one response to one positive stimulus, but requires the absence of that response for one trial block daily: one trial block consisted of twelve 4-minute stimulus intervals interspersed by a correct response to the positive stimulus; no reinforcement is given in the presence of the negative stimulus. When the discrimination had been established by statistical definition, extinction trials were begun, and were continued until no response was emitted for one day's trial block. This procedure allowed made use of the S_{D1} , S_{D2} or the S_D , S_{Δ} paradigms have been remiss in not recognizing the difference between the number of trials to criterion data.

It was demonstrated that the S_D , S_{Δ} paradigm, or generalizations drawn from one training paradigm might not be applicable to conditions and conclusions inherent in the other paradigm. An exception to this is a study by Honig in which attention is called to the particular

Honig, *op. cit.*

paradigm used.¹

trials. In the present study, measures of acquisition and extinction were made in order to compare directly a discrimination conditioned by the S_D , S_{delta} paradigm to the same discrimination conditioned by the S_{D1} , S_{D2} paradigm. Eight pigeons assigned to the S_D , S_{delta} paradigm, and eight pigeons assigned to the S_{D1} , S_{D2} paradigm were conditioned by each of these procedures to discriminate between a red and a green stimulus light in a modified Skinner box. The two stimuli were presented in the successive manner: that is, one stimulus was presented in each trial interval. Reinforcement was delivered on a variable interval schedule. Each animal was conditioned for one trial block daily: one trial block consisted of twelve 4-minute stimulus intervals interspersed by a 1-minute dark period. When the discrimination had been established by statistical definition, extinction trials were begun, and were continued until no response was emitted for one day's trial block. This procedure allowed the collection of correct and error response data, and number of trials to criterion data.

It was demonstrated that the S_D , S_{delta} paradigm, which called for one response to one positive stimulus and no response to the negative stimulus, facilitated the

¹Honig, op. cit.

acquisition of the discrimination by significantly fewer trials. No difference between the two paradigms was found in resistance to extinction as measured by number of trials. When the magnitude of difference between correct and error responses during extinction was compared for the two groups, however, it was evident that the discrimination formed by the S_D , S_{Δ} paradigm was more precisely defined. The examination of the magnitude of difference between correct and error responses for the last six discrimination trials and the extinction trials determined the expected decrement in definition of the discrimination by the S_{D1} , S_{D2} group. An unexpected increment in the precision of the discrimination from discrimination trials to extinction trials was found for the S_D , S_{Δ} group. Since post-discrimination gradients and evidence from other studies failed to provide a clue to this finding, it remains unexplained.

There is reason to suspect on the basis of the data presented that the S_D , S_{Δ} and the S_{D1} , S_{D2} paradigms of conditioning the same discrimination may lead to different learning. At least it may be concluded that measures taken from one of these paradigms cannot be expected to reflect the same processes as measures taken from the other paradigm. The disparity of difference between the correct and error responses for the two groups

emphasizes the hazard in applying conclusions or theoretical positions based on one paradigm to data or conclusions arising from another paradigm.

The question arises as to whether the unexpected increment in the precision of the discrimination from discrimination trials to extinction trials of the S_D , S_{delta} group was, in fact, invalid due to some variable intrinsic to this experiment, or whether it has gone unnoticed in other studies. The need for further experimental evidence is clearly indicated.

It must be pointed out that extinction proved to be a poor measure of the conditioned discrimination. Extinction procedures measured resistance to the extinction of the response performance, but not necessarily of the discrimination itself! A reversal problem, which would maintain the response performance, but "extinguish" the discrimination, is suggested instead.

Examination of post-discrimination gradients for the S_{D1} , S_{D2} paradigm (similar to those done by Hanson¹ and Honig² for the S_D , S_{delta} paradigm) would be fruitful. In addition the measurement of interaction of variables which influence the discrimination, as well as the resulting data, is essential; continued attention to the identification

¹Hanson, op. cit.

²Honig, op. cit.

of variables which may be influencing discrimination data and its measurement cannot be stressed too strongly.

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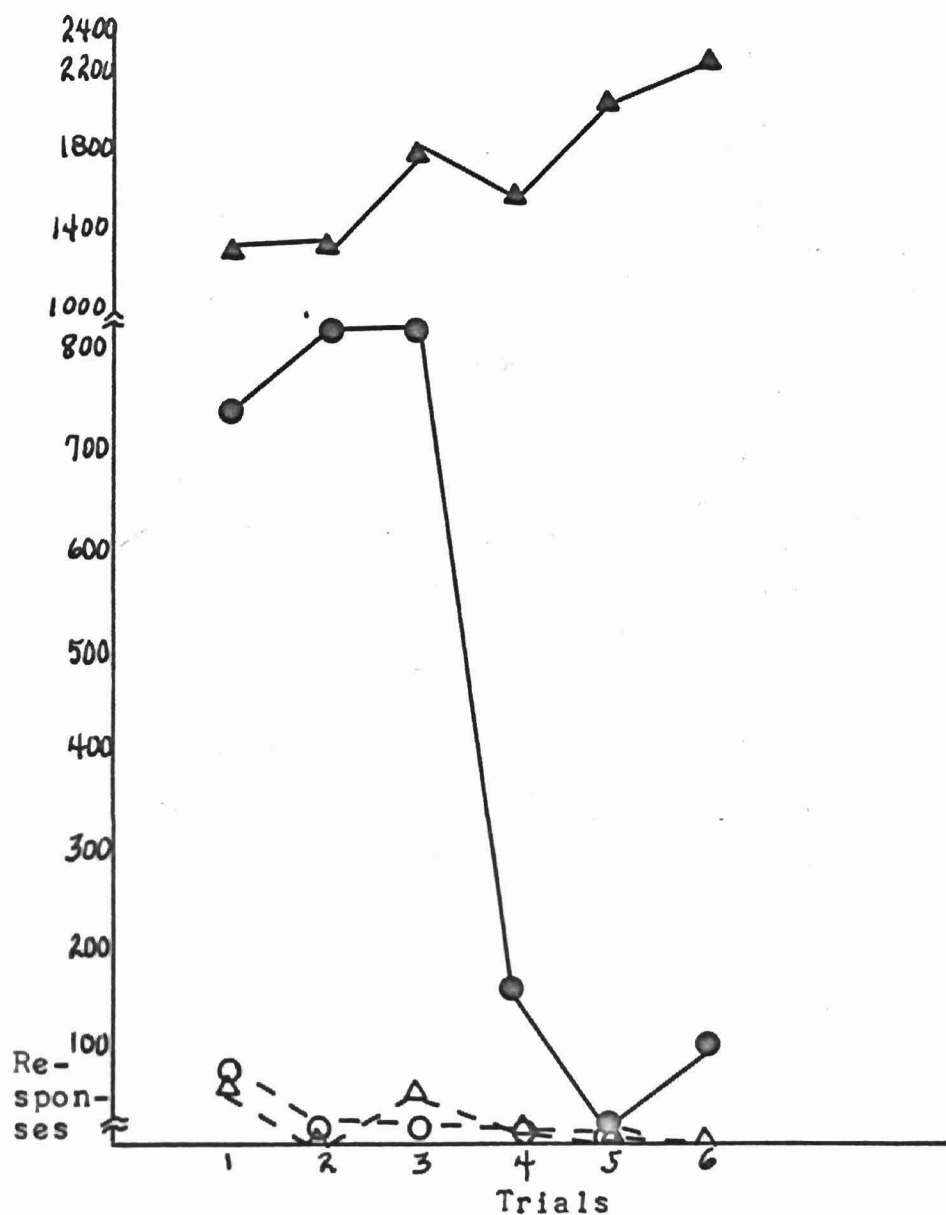
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APPENDIXES

APPENDIX A

Learning Curves of
Individual Discrimination Acquisition

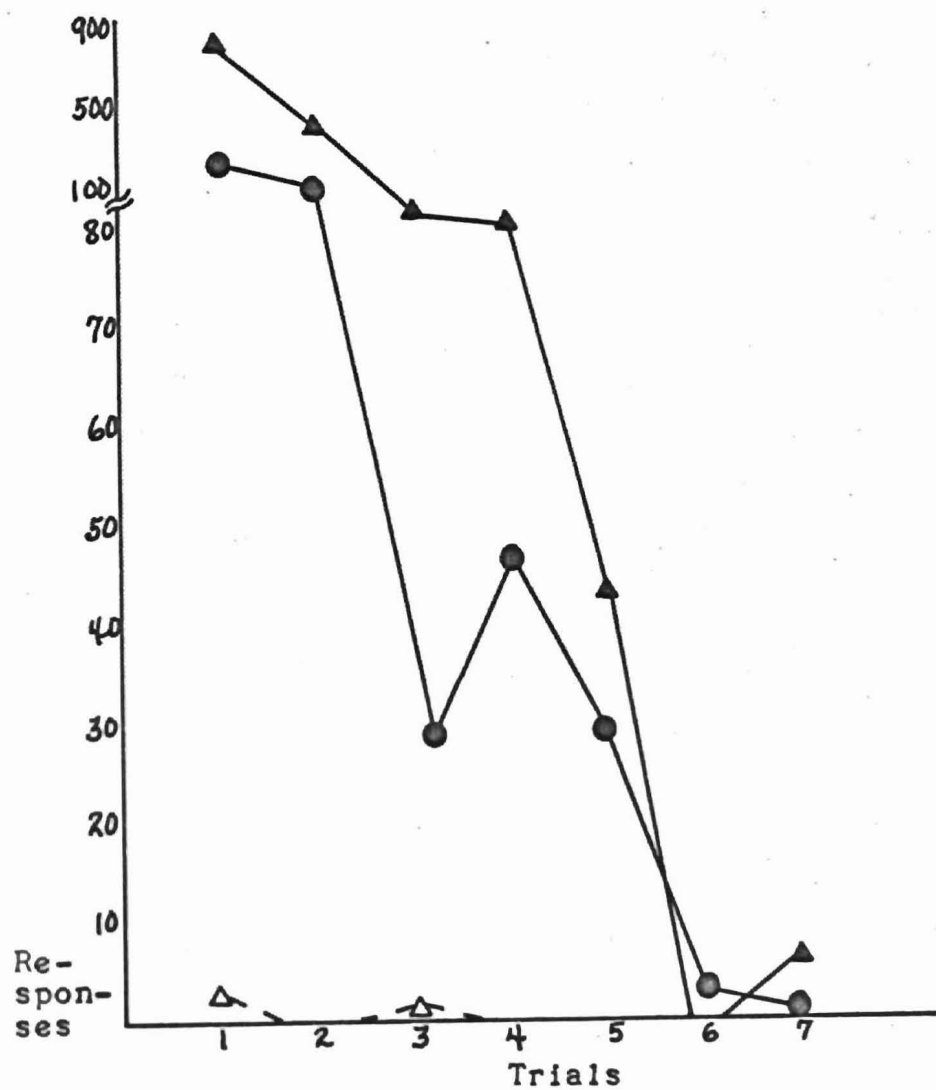


▲-▲ Correct, Key 2 ●-● Error, Key 2
 Δ-Δ Error, Key 1 ○-○ Error, Key 1

Group I - Animal B-2

S_D , S_{delta} Paradigm

Acquisition: 6 Trials

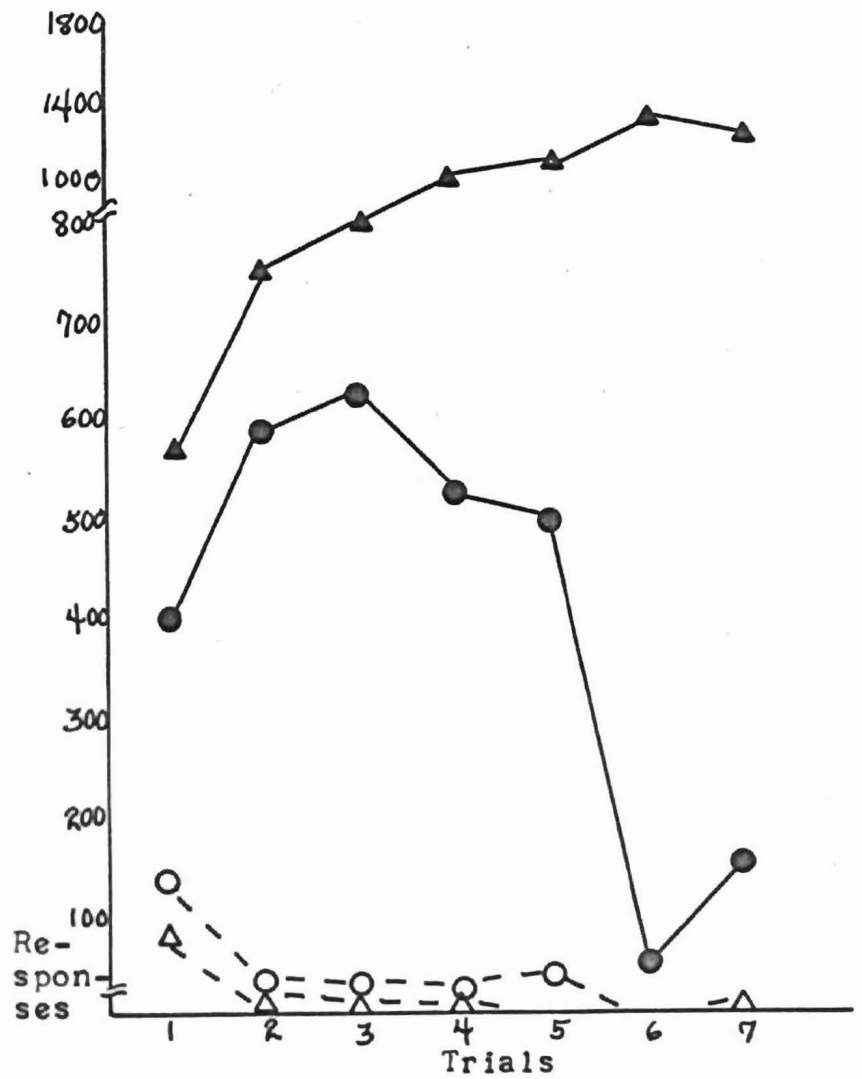


▲—▲ Correct, Key 2 ●—● Error, Key 2
 △—△ Error, Key 1 ○—○ Error, Key 1

Group I - Animal B-4

S_D , S_{Δ} Paradigm

Extinction: 7 Trials

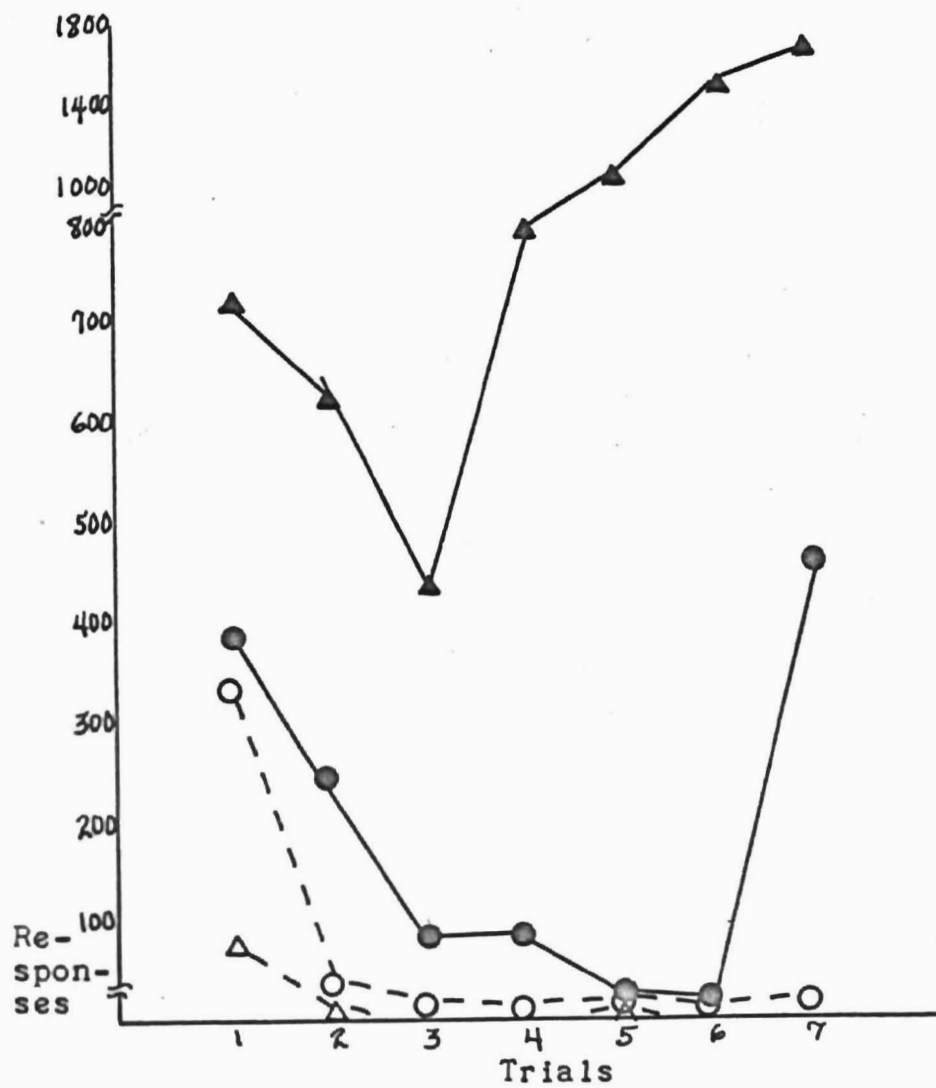


▲-▲ Correct, Key 2 ●-● Error, Key 2
 Δ-Δ Error, Key 1 ○-○ Error, Key 1

Group I - Animal A-4

S_D , S_{Δ} Paradigm

Acquisition: 7 Trials

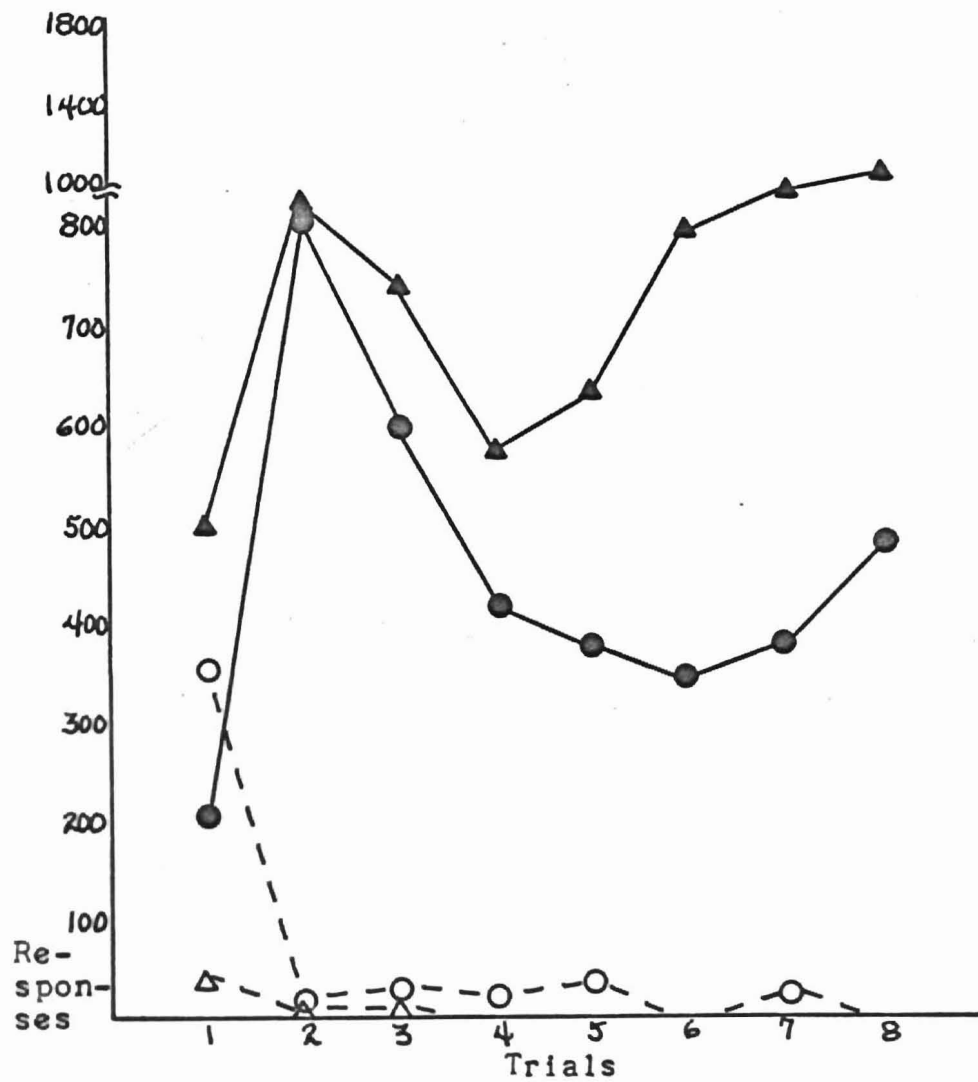


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 △—△ Error, Key 1 ○—○ Error, Key 1

Group I - Animal A-2

S_D , S_{δ} Paradigm

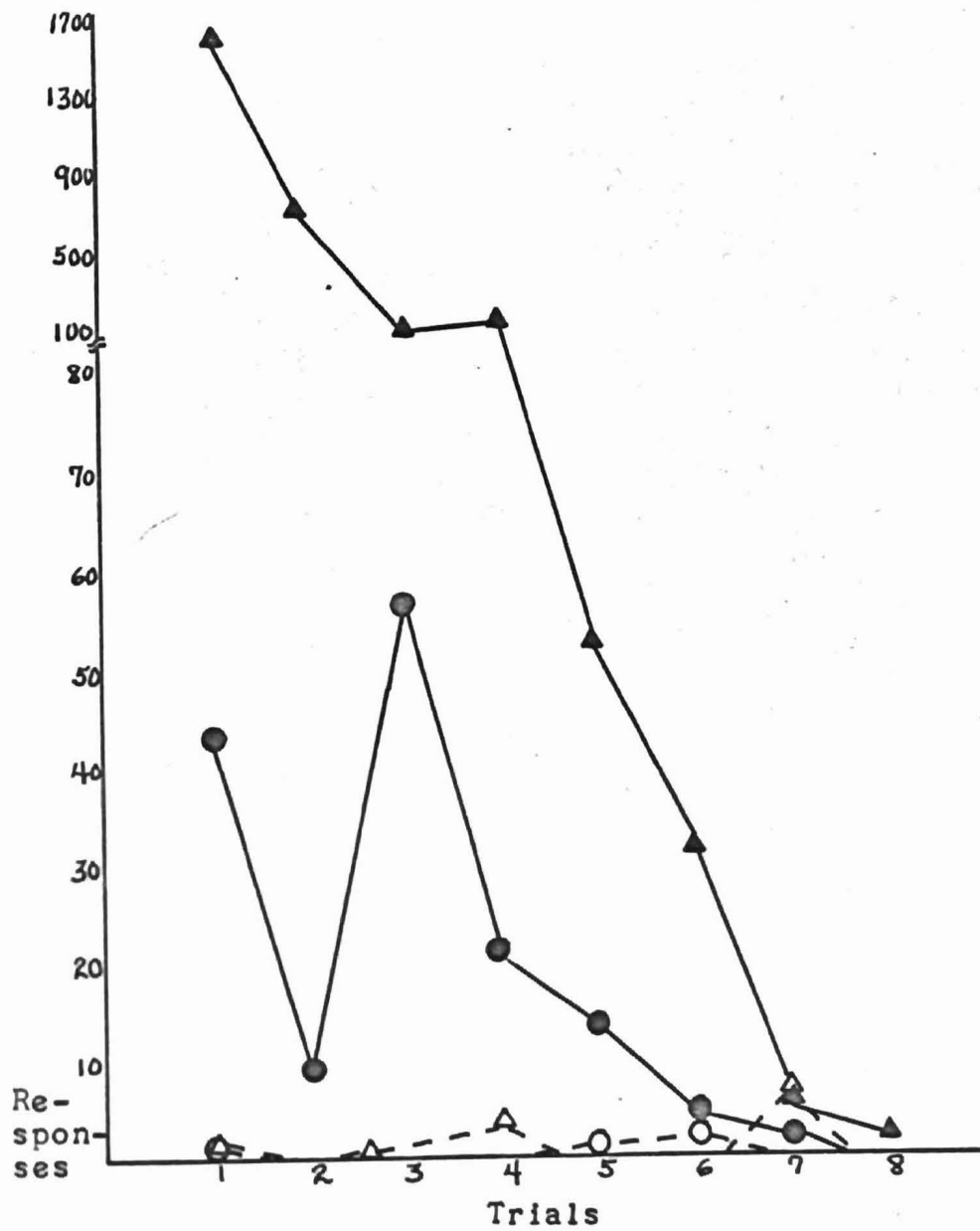
Acquisition: 7 Trials



▲—▲ Correct, Key 1 ●—● Error, Key 1
 Δ—Δ Error, Key 2 ○—○ Error, Key 2

Group I - Animal B-3
 S_D , S_{Δ} Paradigm
 Acquisition: 8 Trials

215966

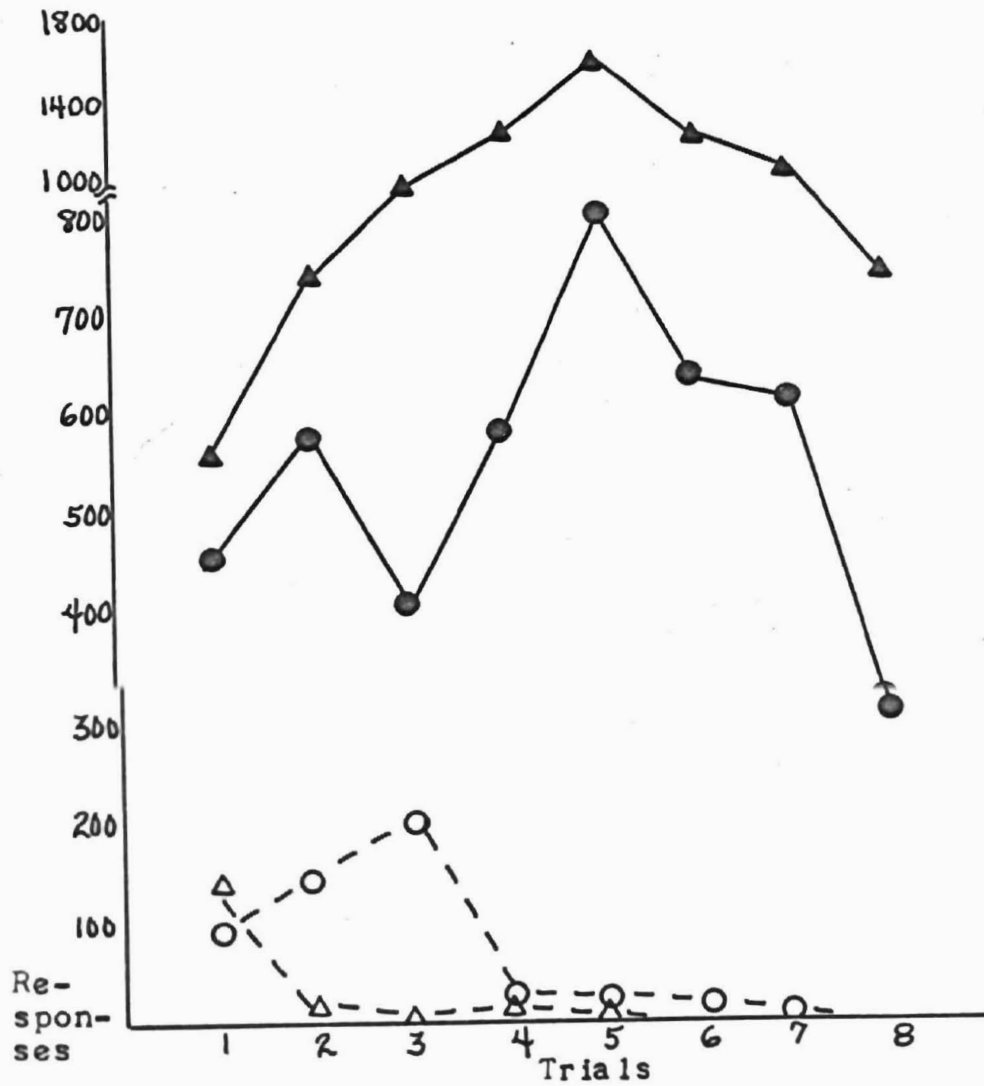


▲—▲ Correct, Key 1 ●—● Error, Key 1
 △—△ Error, Key 2 ○—○ Error, Key 2

Group I - Animal B-6

S_D , S_{Δ} Paradigm

Extinction: 8 Trials



▲—▲ Correct, Key 1

●—● Error, Key 1

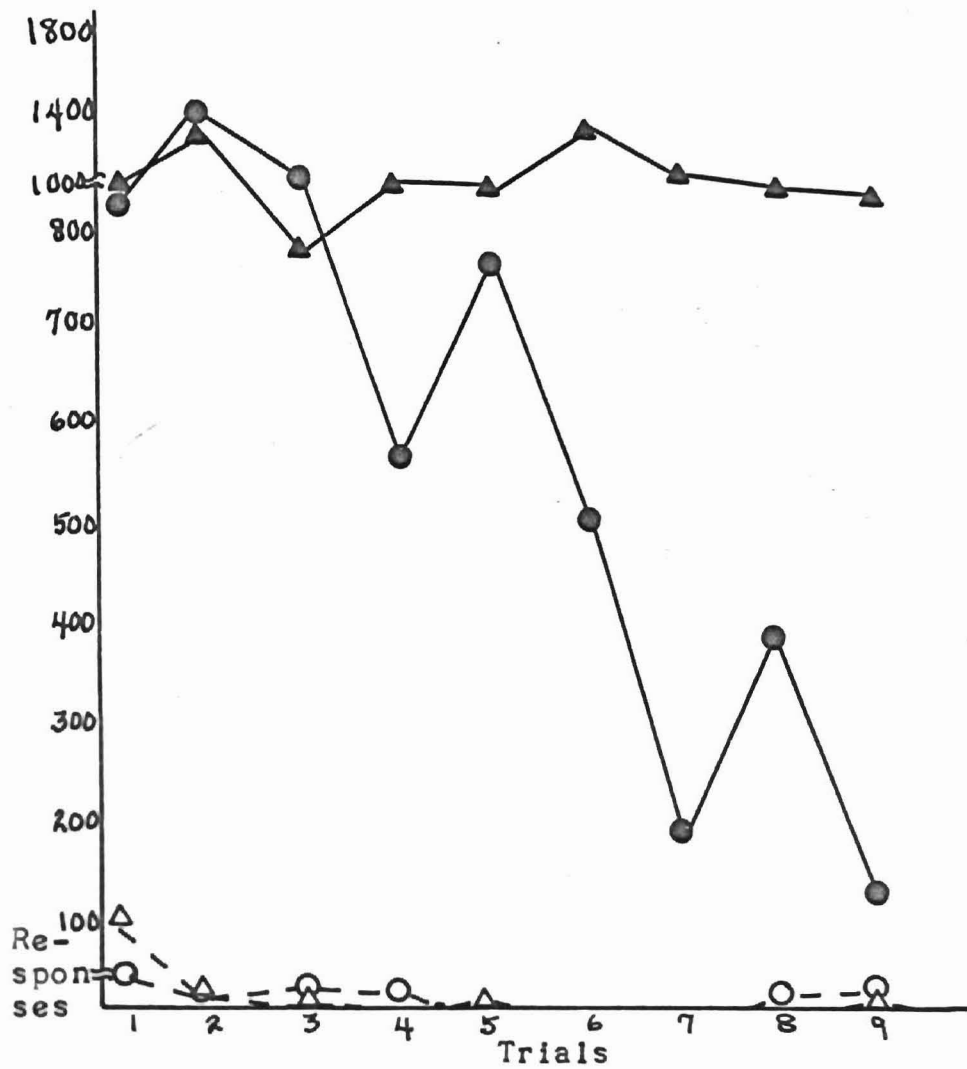
Δ—Δ Error, Key 2

○—○ Error, Key 2

Group I - Animal A-3

S_D , S_{Δ}

Acquisition: 8 trials

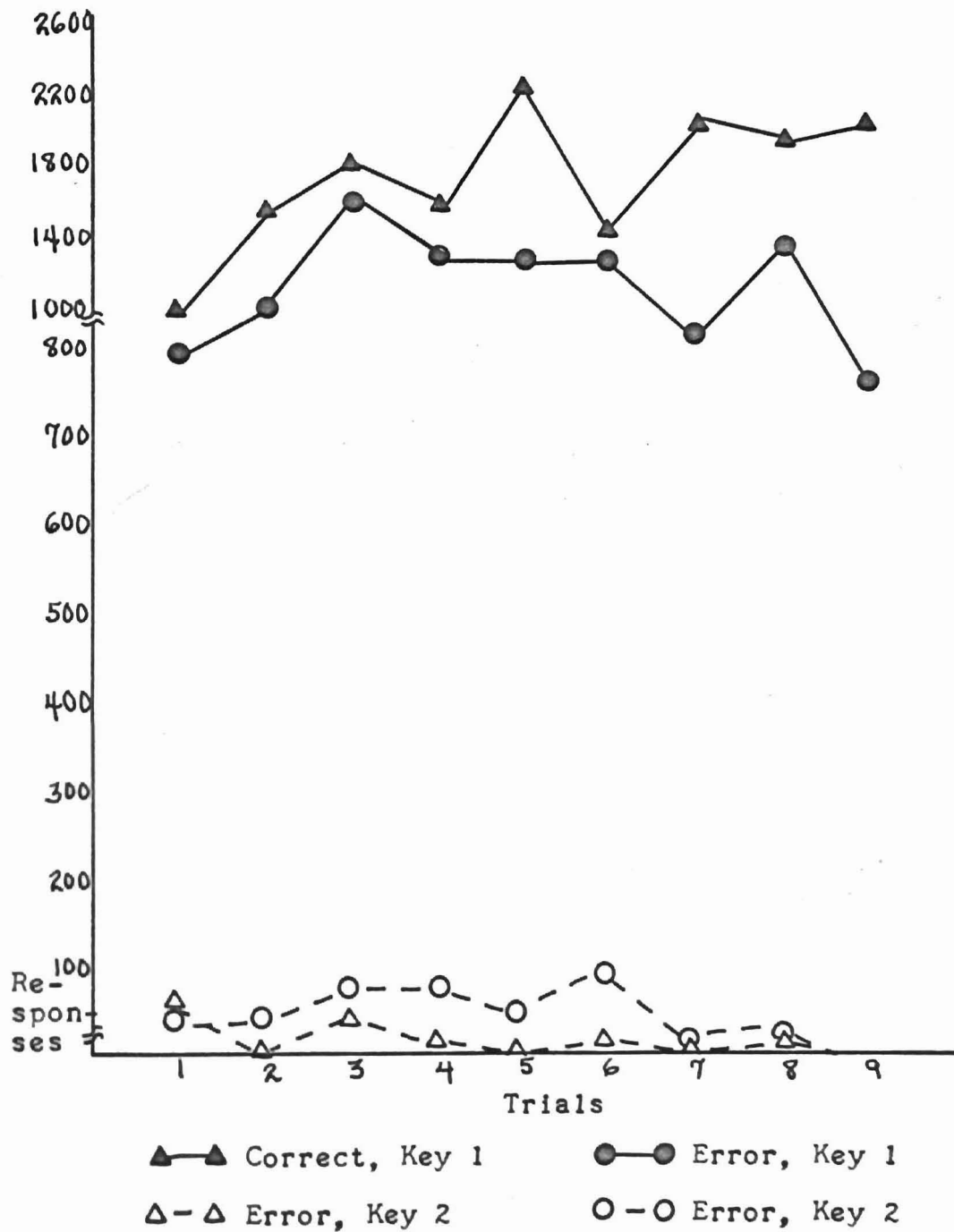


▲-▲ Correct, Key 1 ●-● Error, Key 1
 △-△ Error, Key 2 ○-○ Error, Key 2

Group I - Animal A-5

S_D , S_{Δ} Paradigm

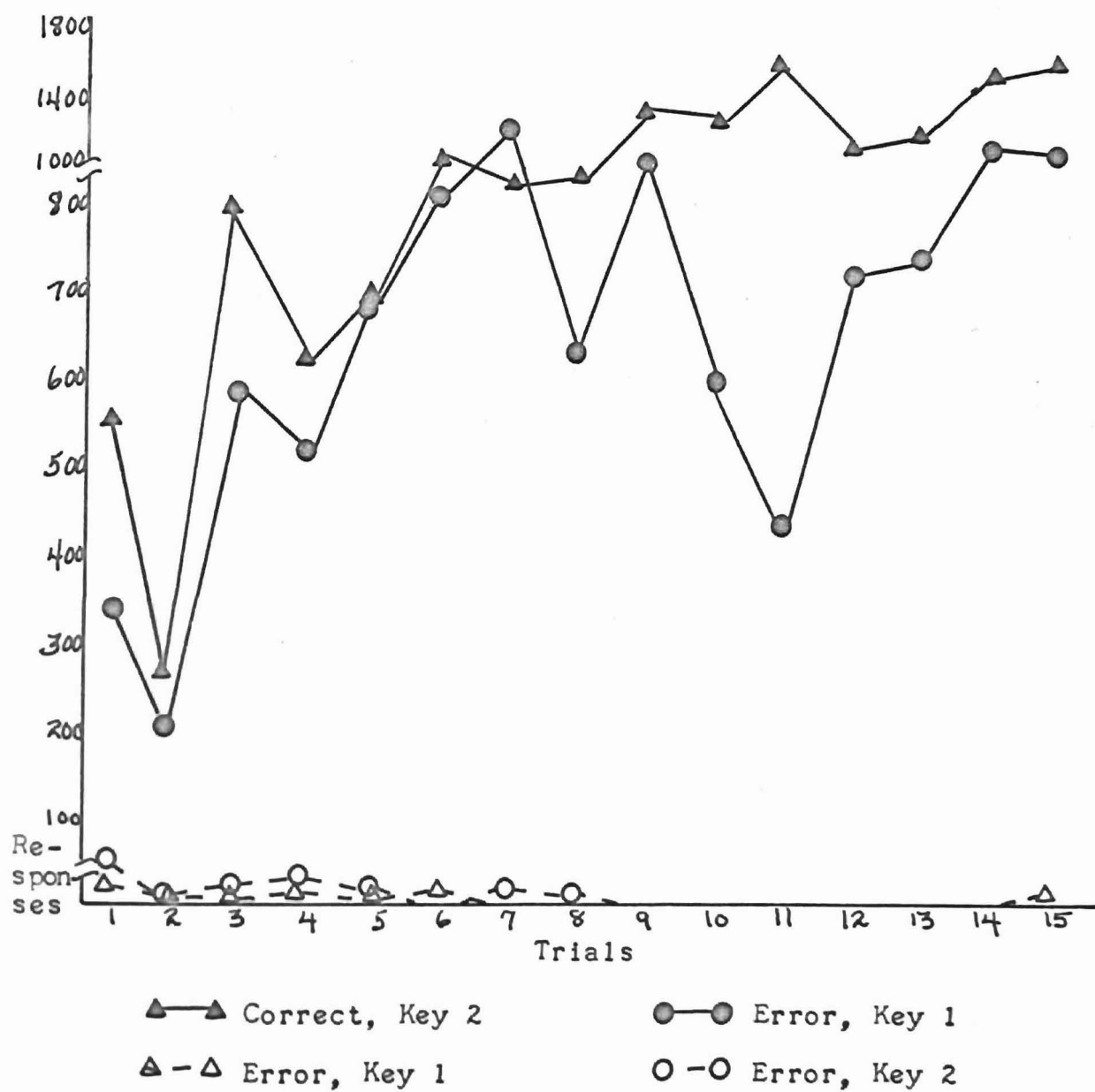
Acquisition: 9 Trials



Group I - Animal B-6

S_D , S_{Δ} Paradigm

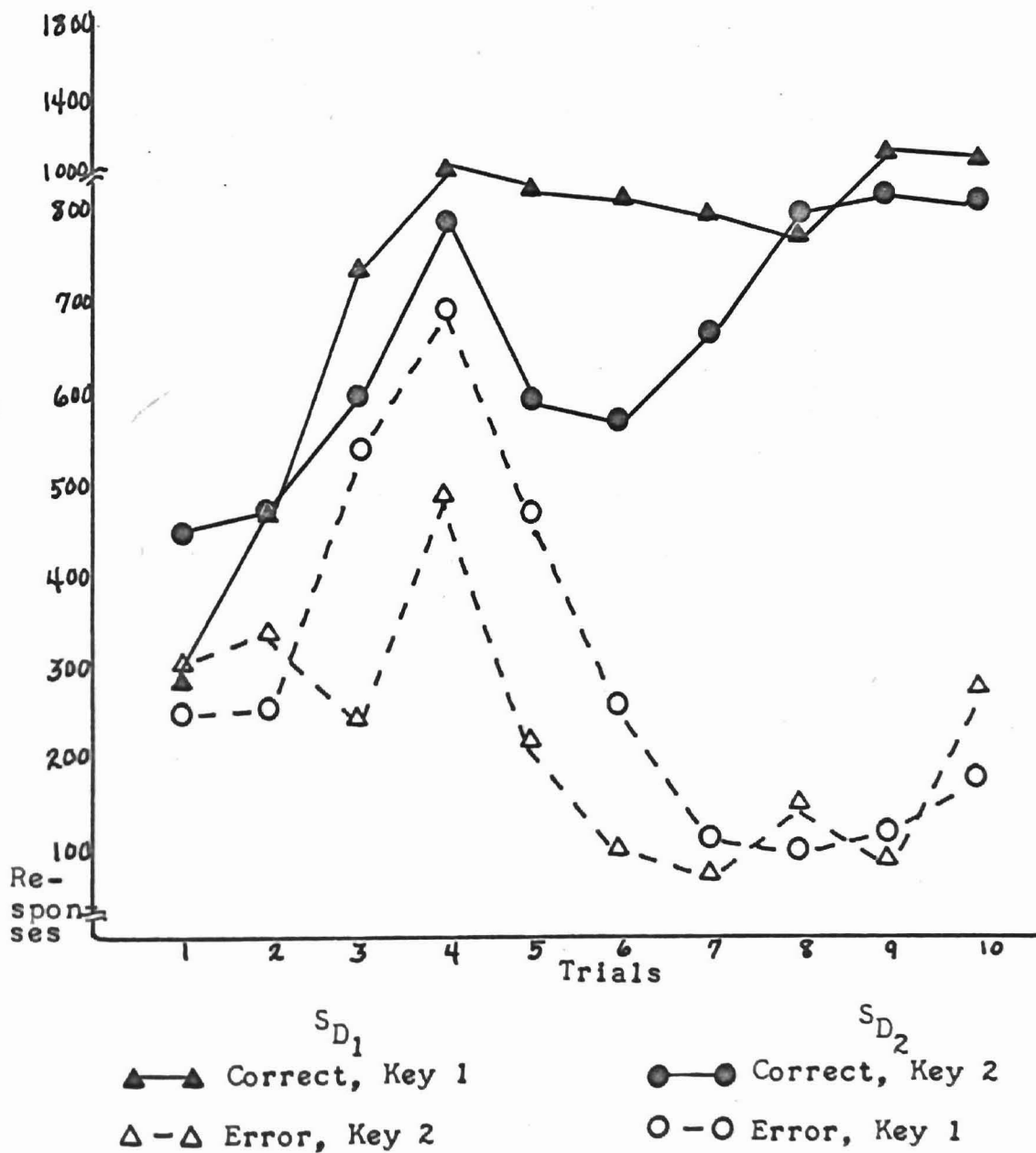
Acquisition: 9 Trials



Group I - Animal B-4

S_D , S_{Δ} Paradigm

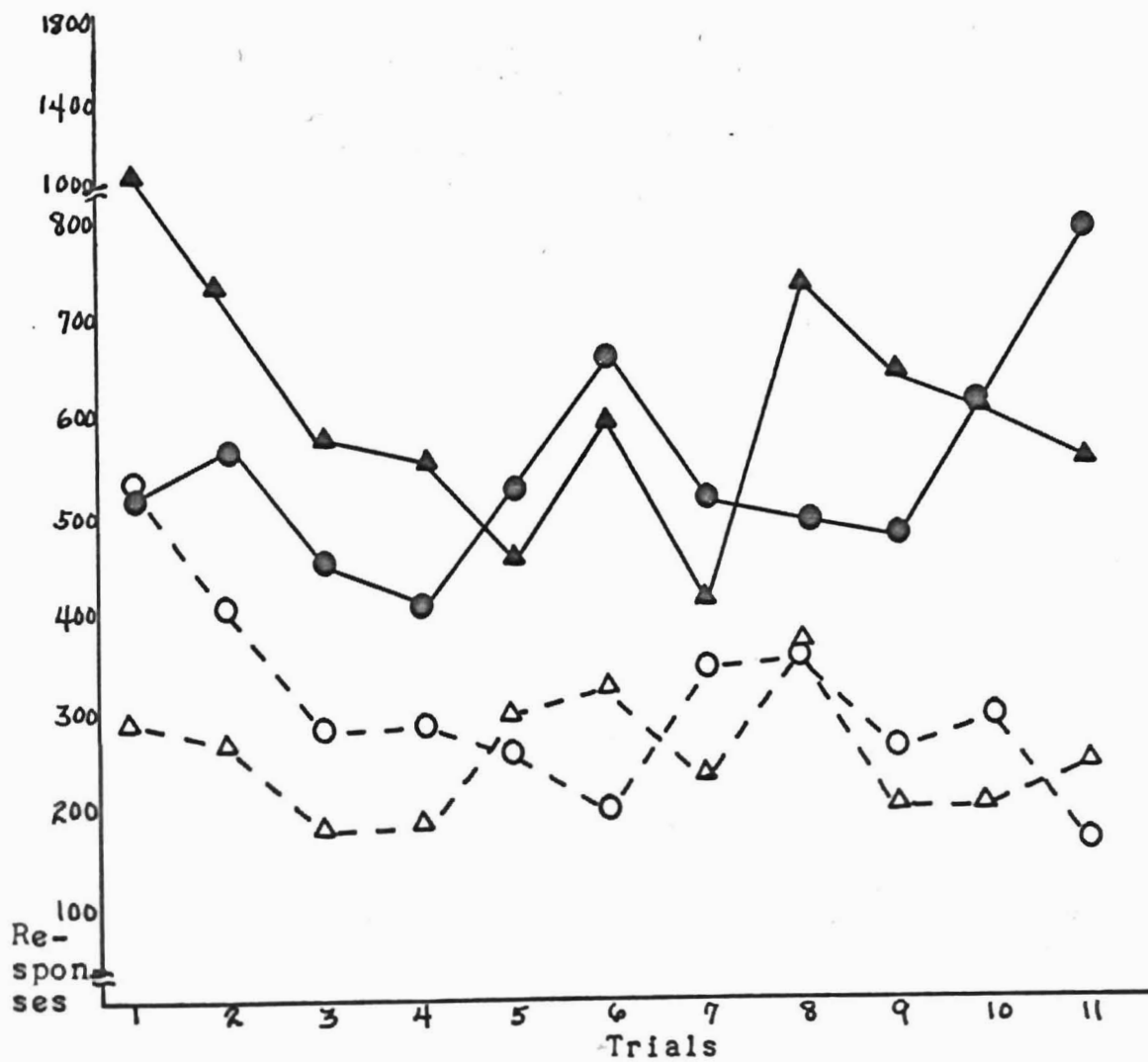
Acquisition: 15 Trials



Group II - Animal A-3

S_{D1} , S_{D2} Paradigm

Acquisition: 10 trials



▲—▲ Correct, Key 2

●—● Correct, Key 1

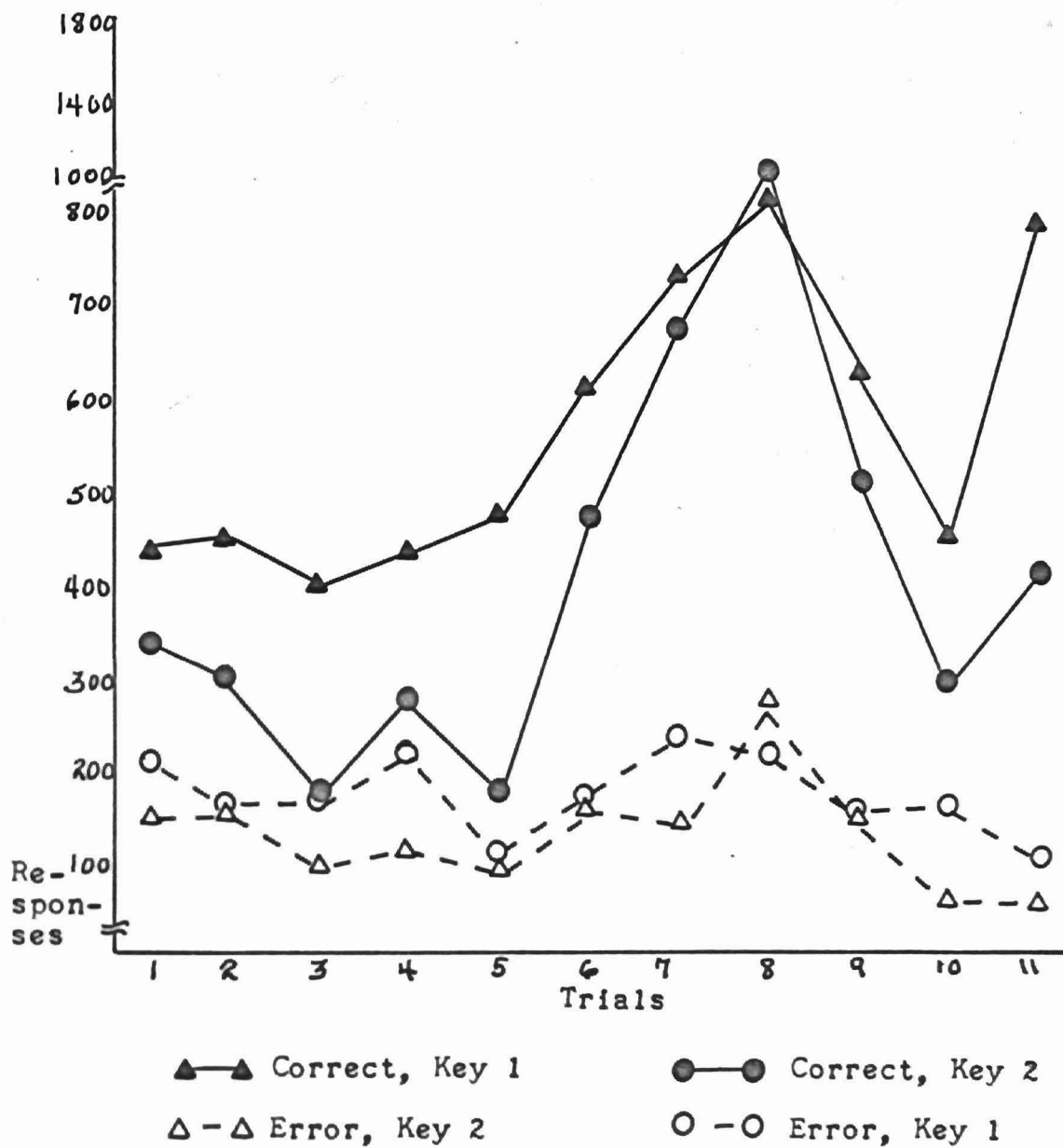
△—△ Error, Key 1

○—○ Error, Key 2

Group II - Animal B-4

S_{D_1} , S_{D_2} Paradigm

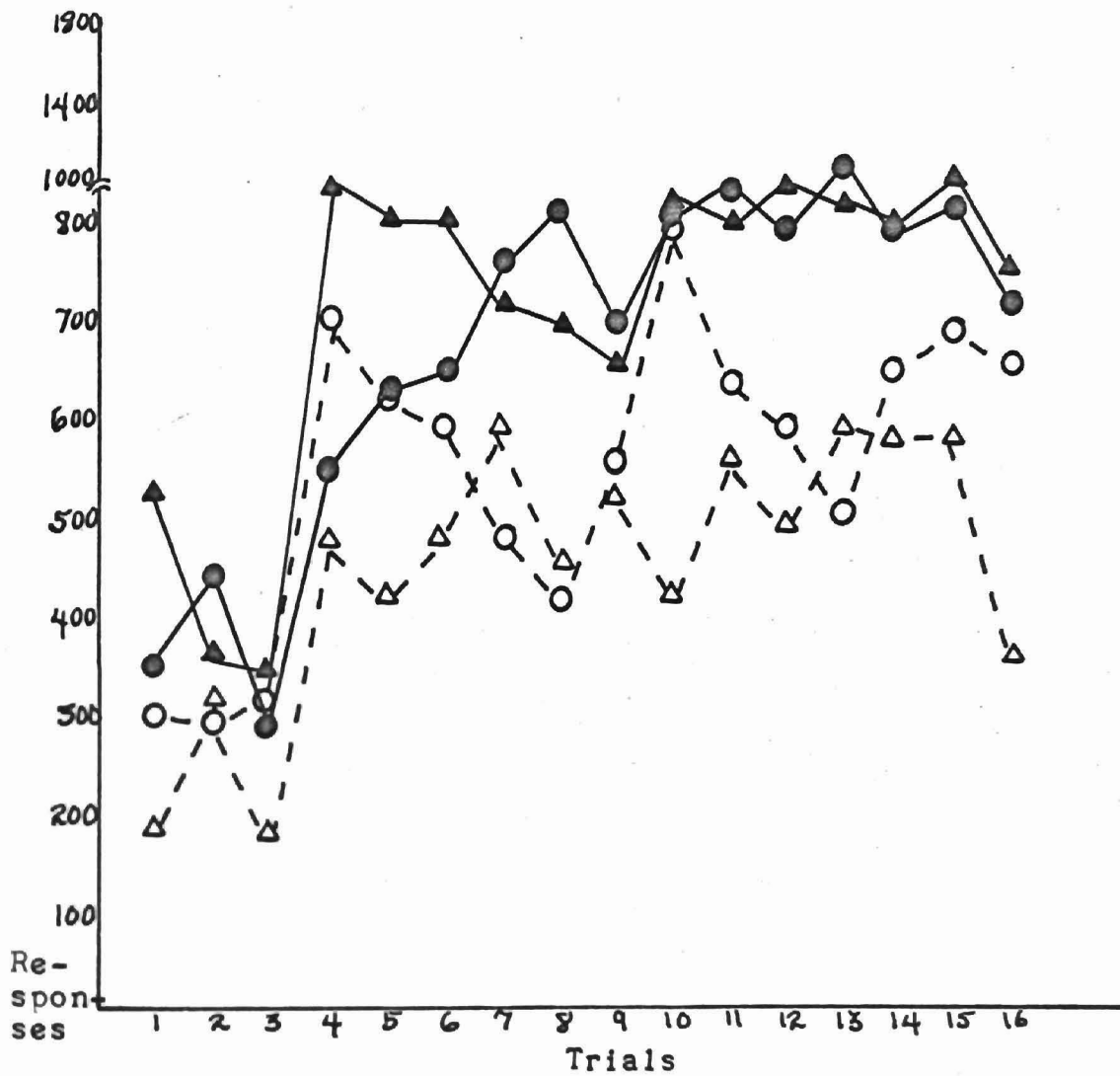
Acquisition: 11 Trials



Group II - Animal A-6

S_{D_1} , S_{D_2} Paradigm

Acquisition: 11 Trials

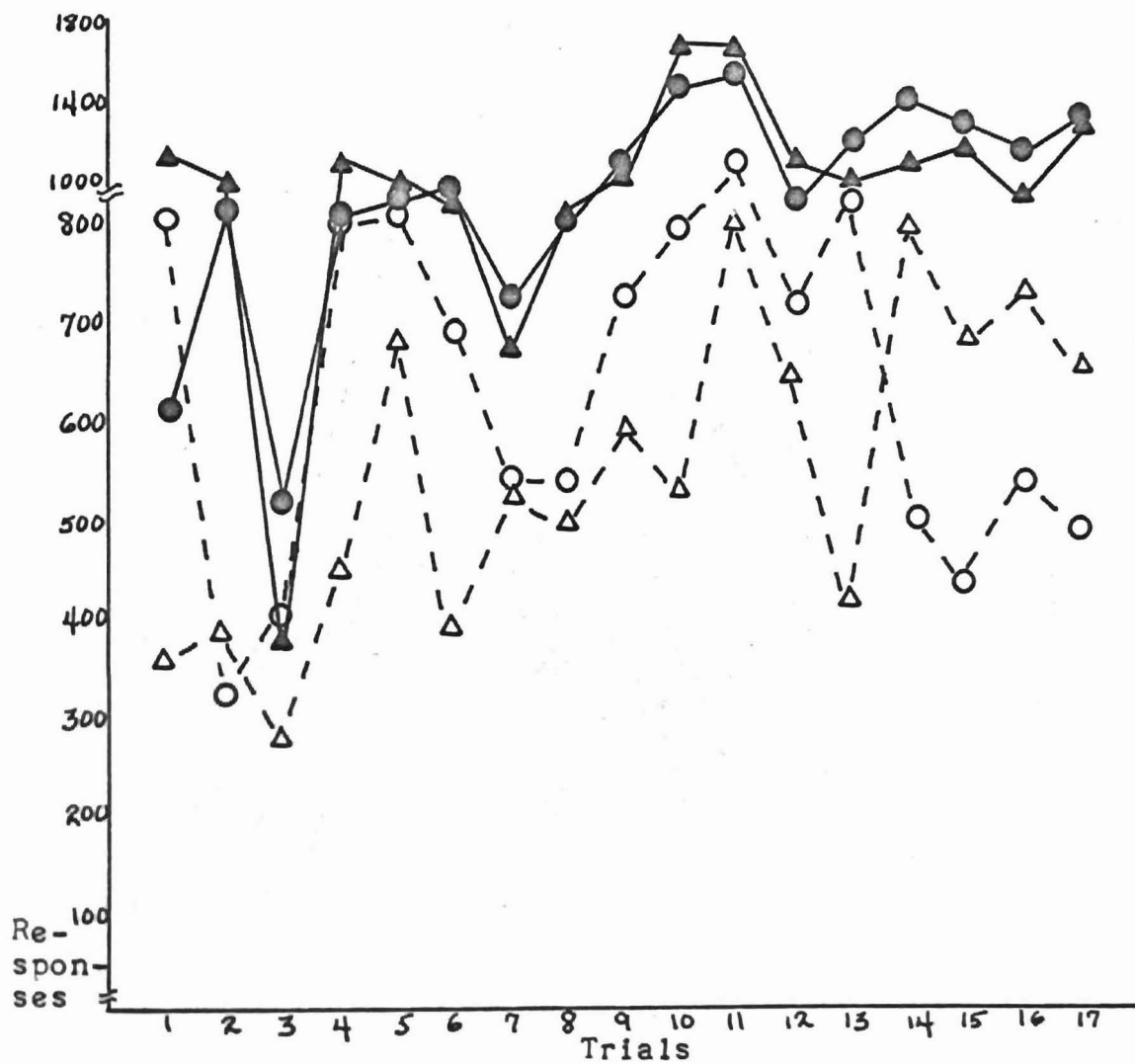


▲—▲ Correct, Key 2 ●—● Correct, Key 1
 △—△ Error, Key 1 ○—○ Error, Key 2

Group II - Animal A-4

S_{D_1} , S_{D_2} Paradigm

Acquisition: 16 trials

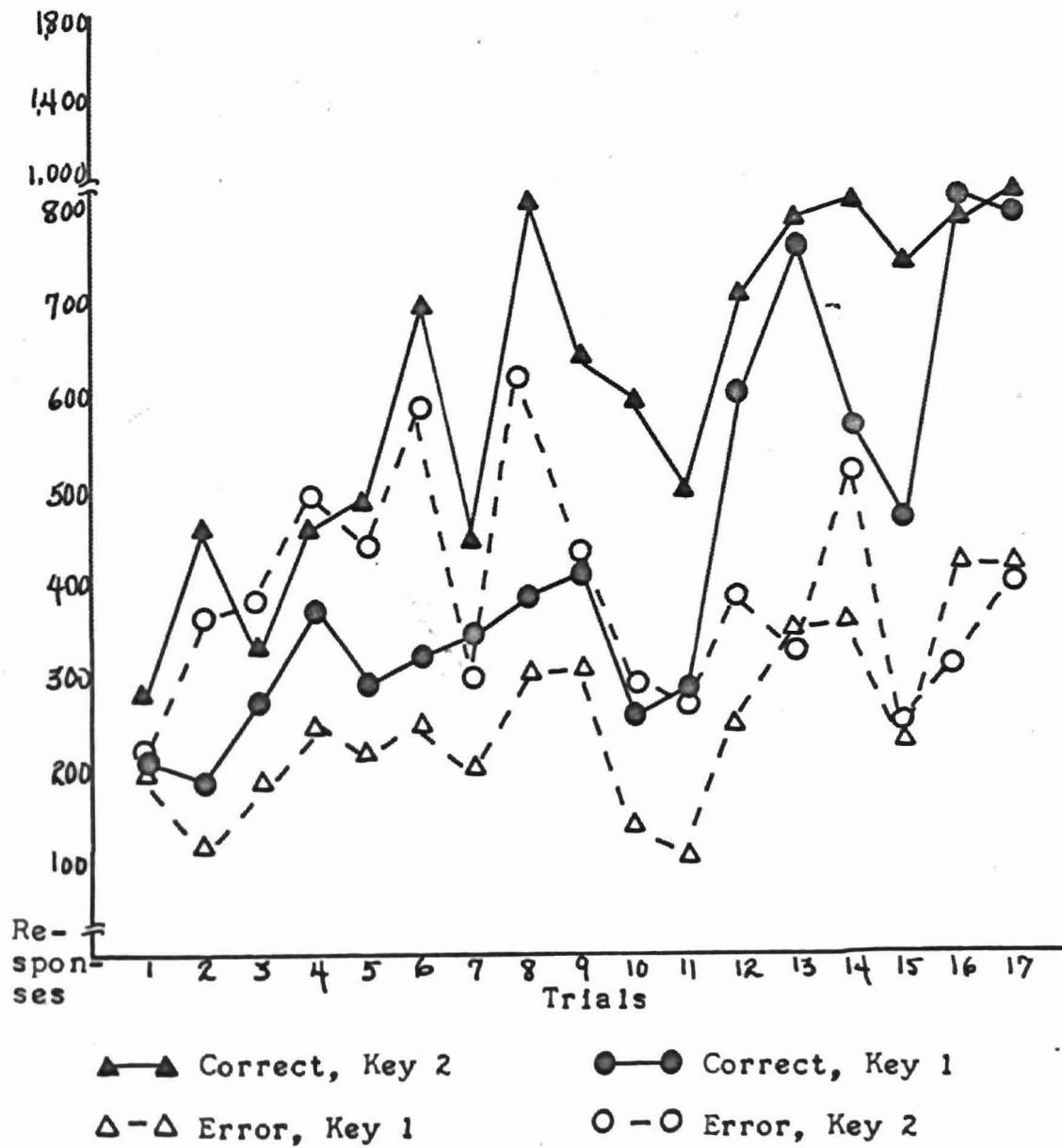


▲—▲ Correct, Key 2 ●—● Correct, Key 1
 Δ—Δ Error, Key 1 ○—○ Error, Key 2

Group II - Animal A-2

S_{D_1} , S_{D_2} Paradigm

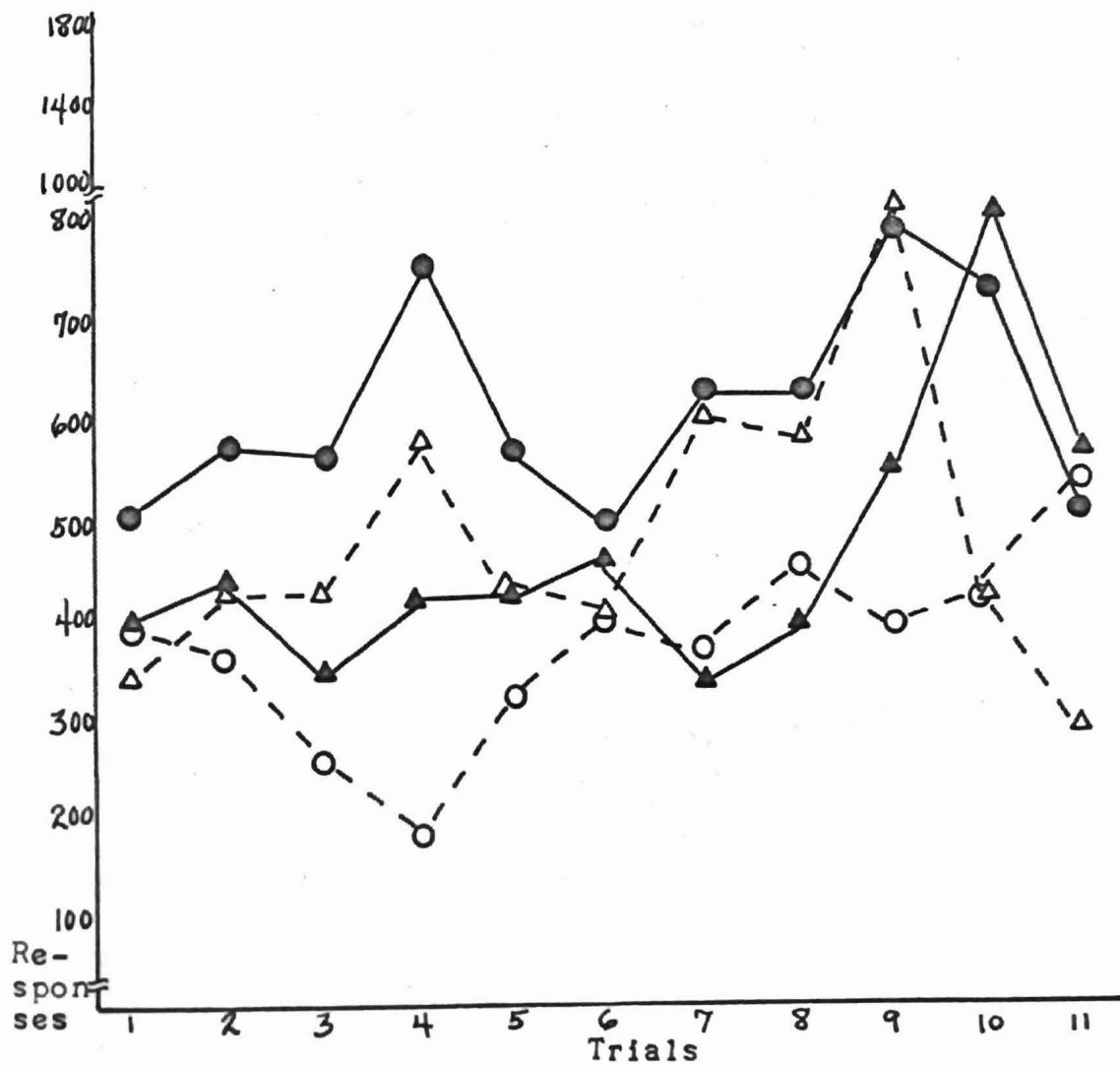
Acquisition: 17 Trials



Group II - Animal B-3

S_{D1} , S_{D2} Paradigm

Acquisition: 17 trials



▲—▲ Correct, Key 1

●—● Correct, Key 2

△—△ Error, Key 2

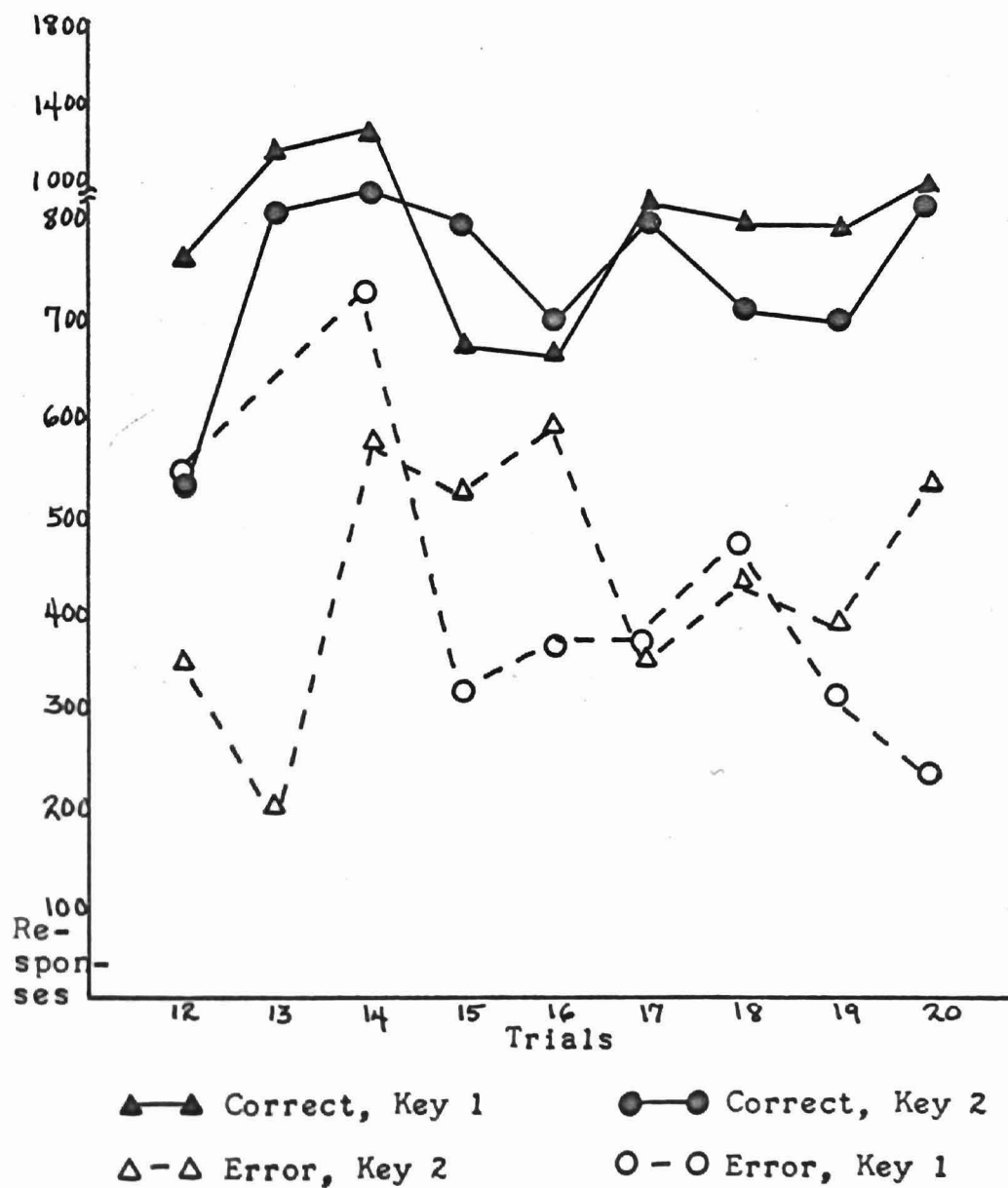
○—○ Error, Key 1

Group II - Animal B-2

S_{D1} , S_{D2} Paradigm

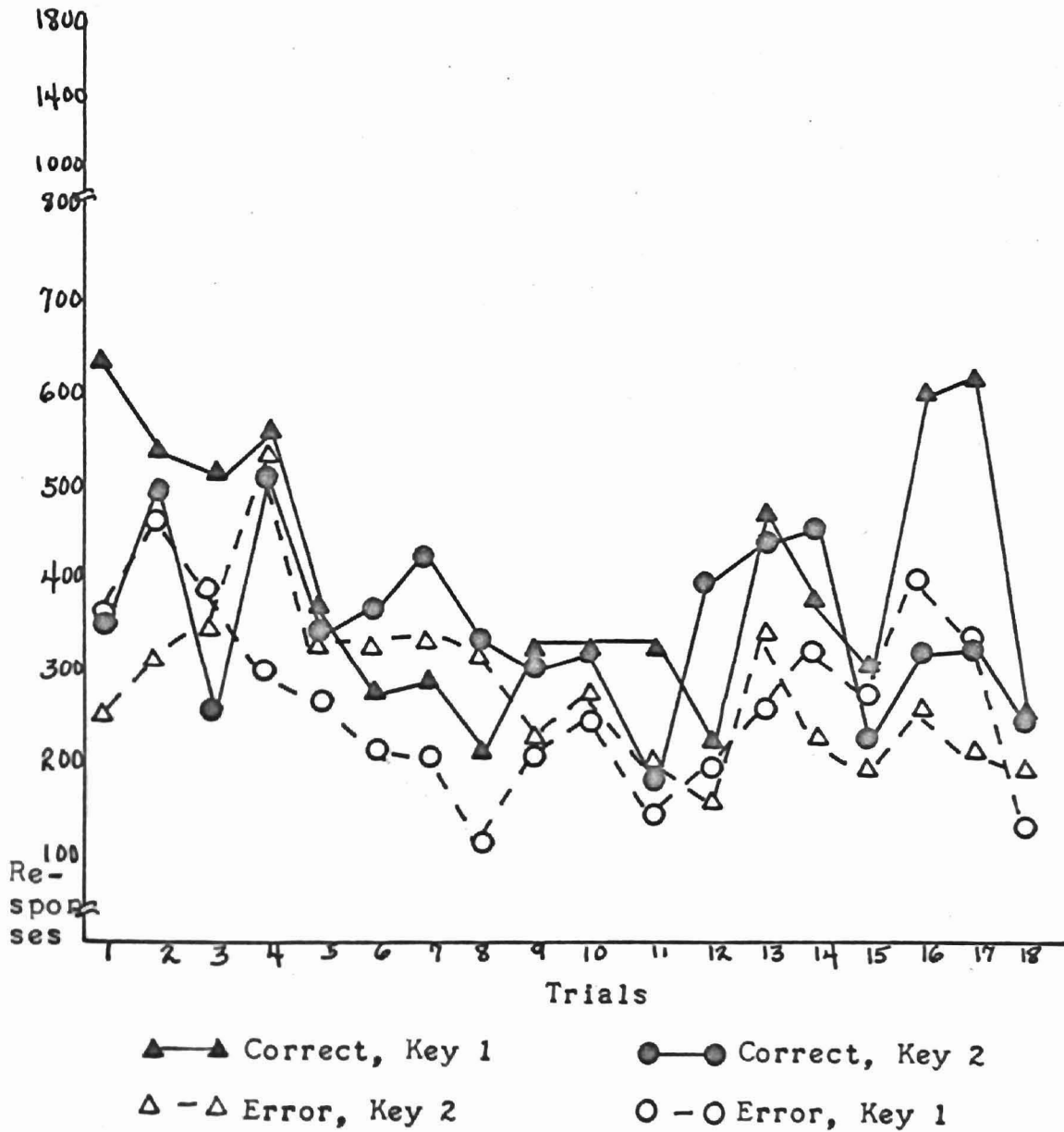
Acquisition: 20 Trials

(continued next page)



Group II - Animal B-2
(cont.)

Acquisition: 20 Trials

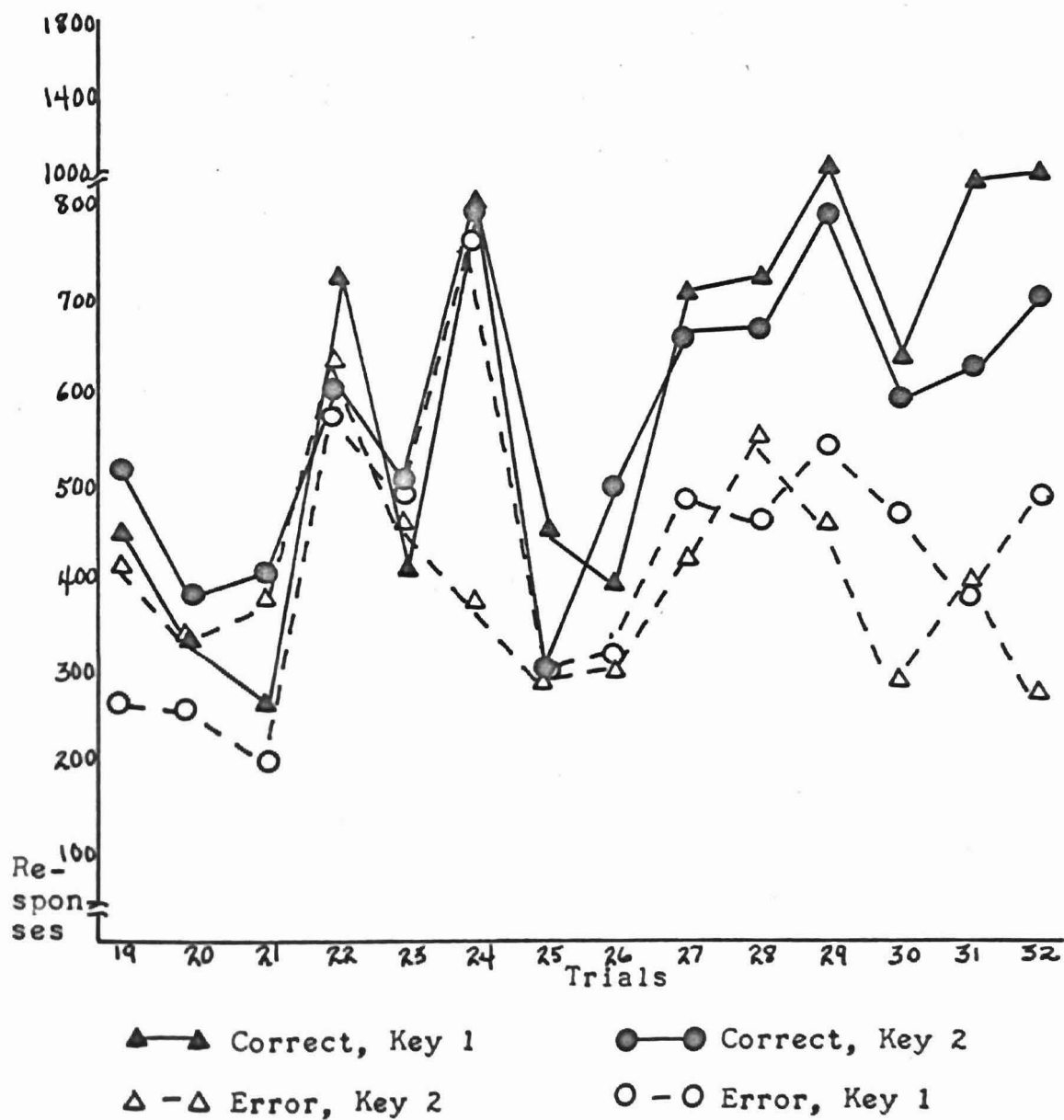


Group II - Animal B-6

S_{D1} , S_{D2} Paradigm

Acquisition: 32 Trials

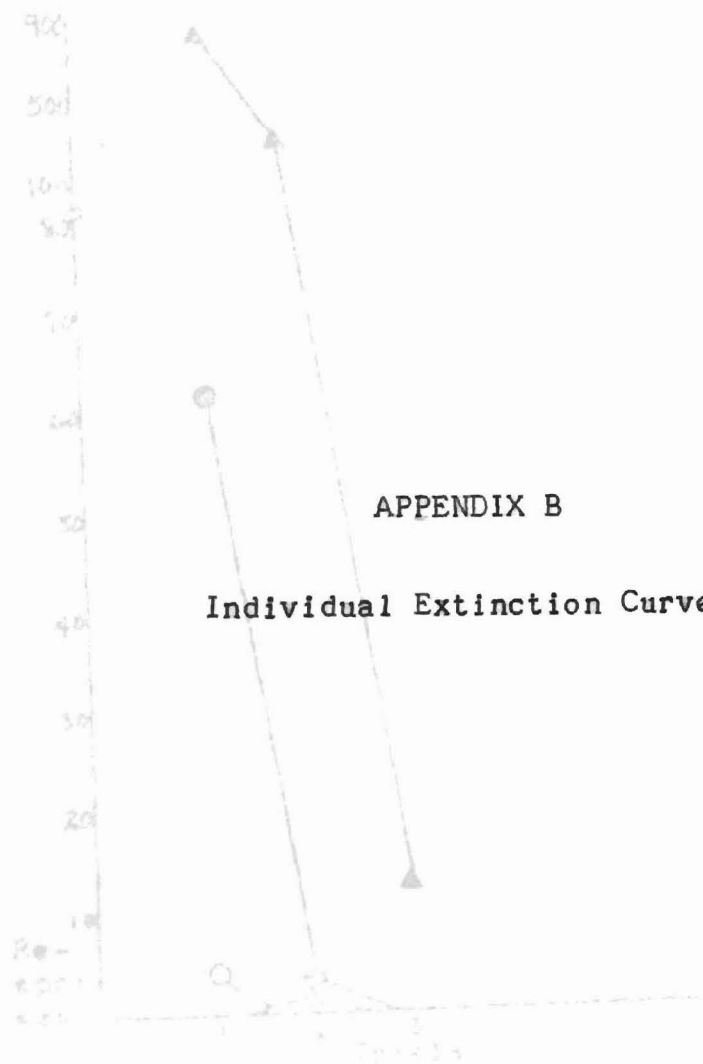
(continued on next page)



Group II - Animal B-6
(continued)

S_{D_1} , S_{D_2} Paradigm

Acquisition: 32 Trials



APPENDIX B

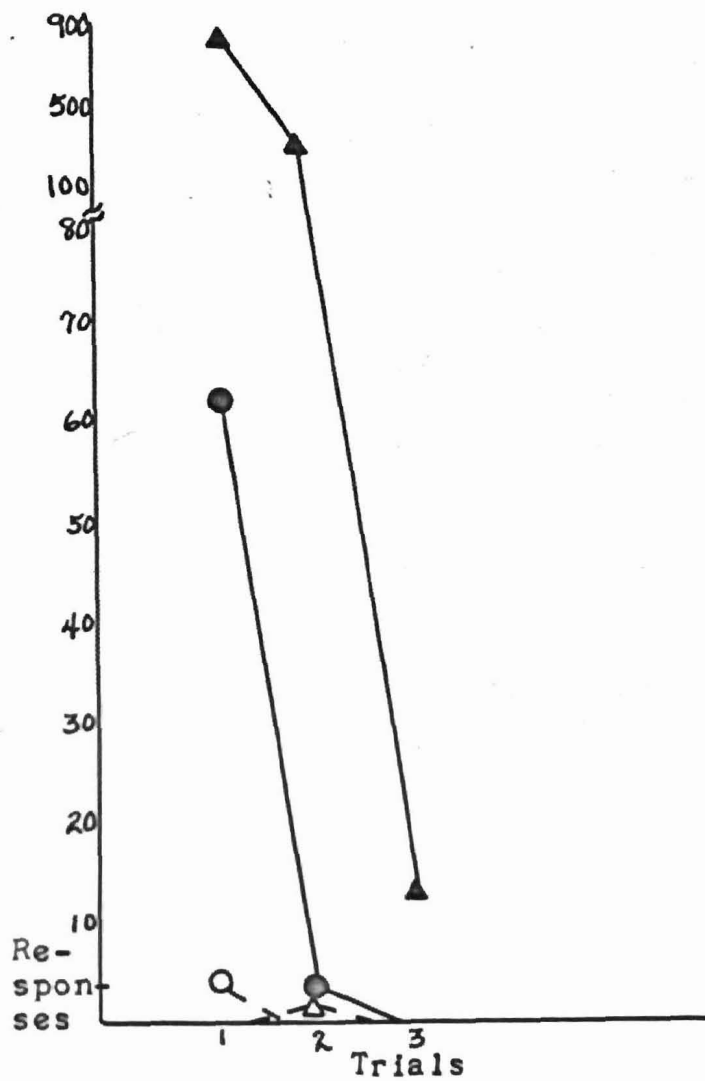
Individual Extinction Curves

▲ - ▲ Correct, Key 15 - ● Error, Key 1
 ▲ - ● Error, Key 2 - ○ - ○ Error, Key 2

Group 1 - Animals A-5

Sp. 3 delta Paradigm

Extinction: 3 Trials

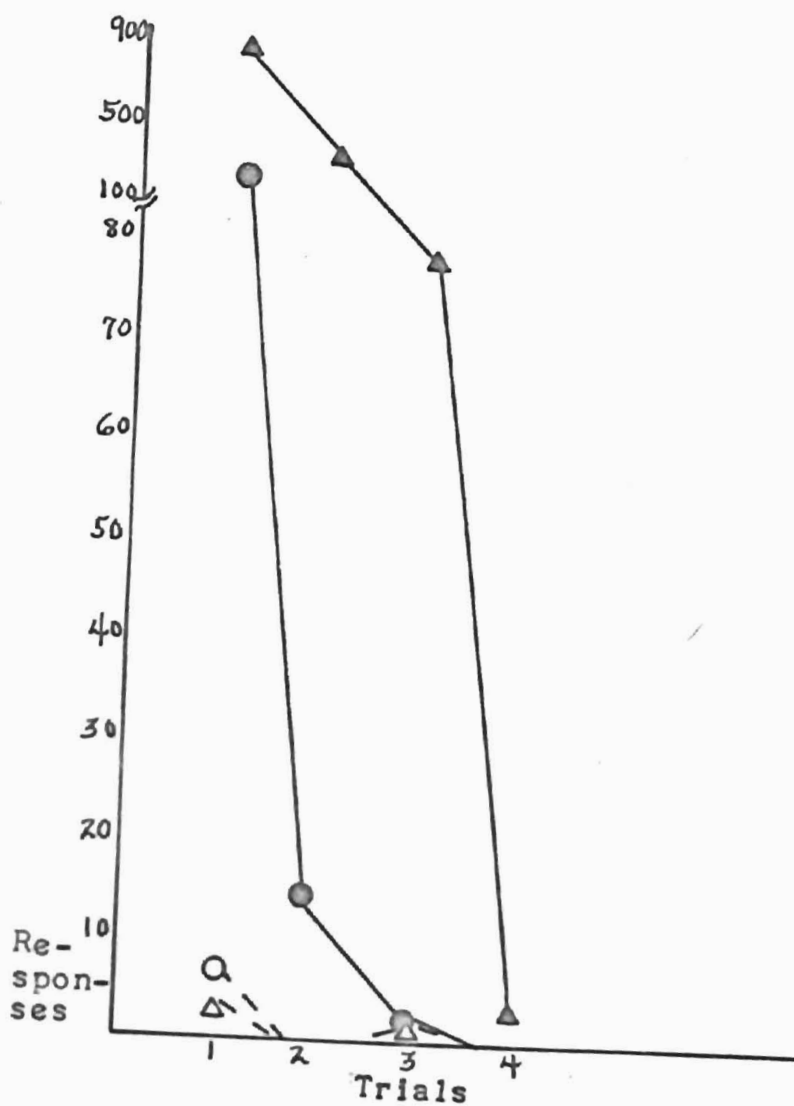


▲—▲ Correct, Key 1 ●—● Error, Key 1
 △—△ Error, Key 2 ○—○ Error, Key 2

Group I - Animal A-5

S_D , S_{δ} Paradigm

Extinction: 3 Trials

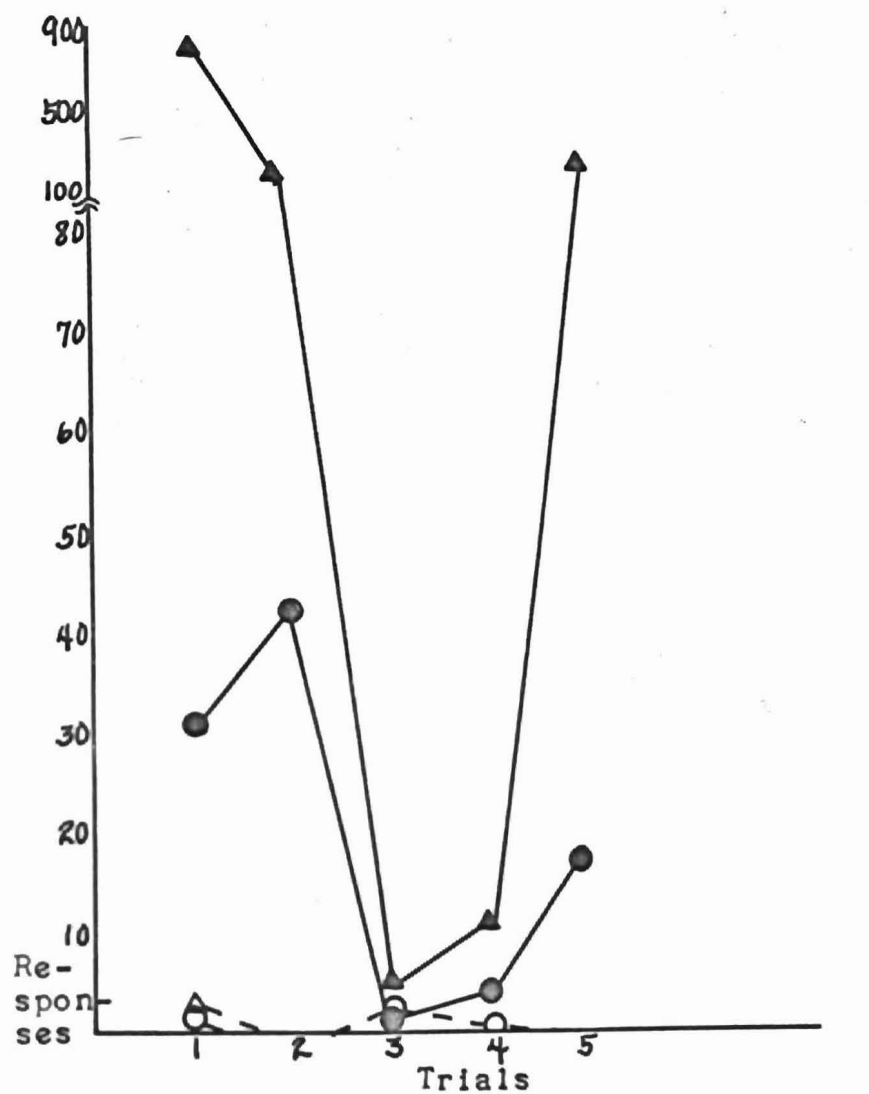


▲-▲ Correct, Key 1 ●-● Error, Key 1
 △-△ Error, Key 2 ○-○ Error, Key 2

Group I - Animal A-3

S_D , S_{Δ} Paradigm

Extinction: 4 Trials

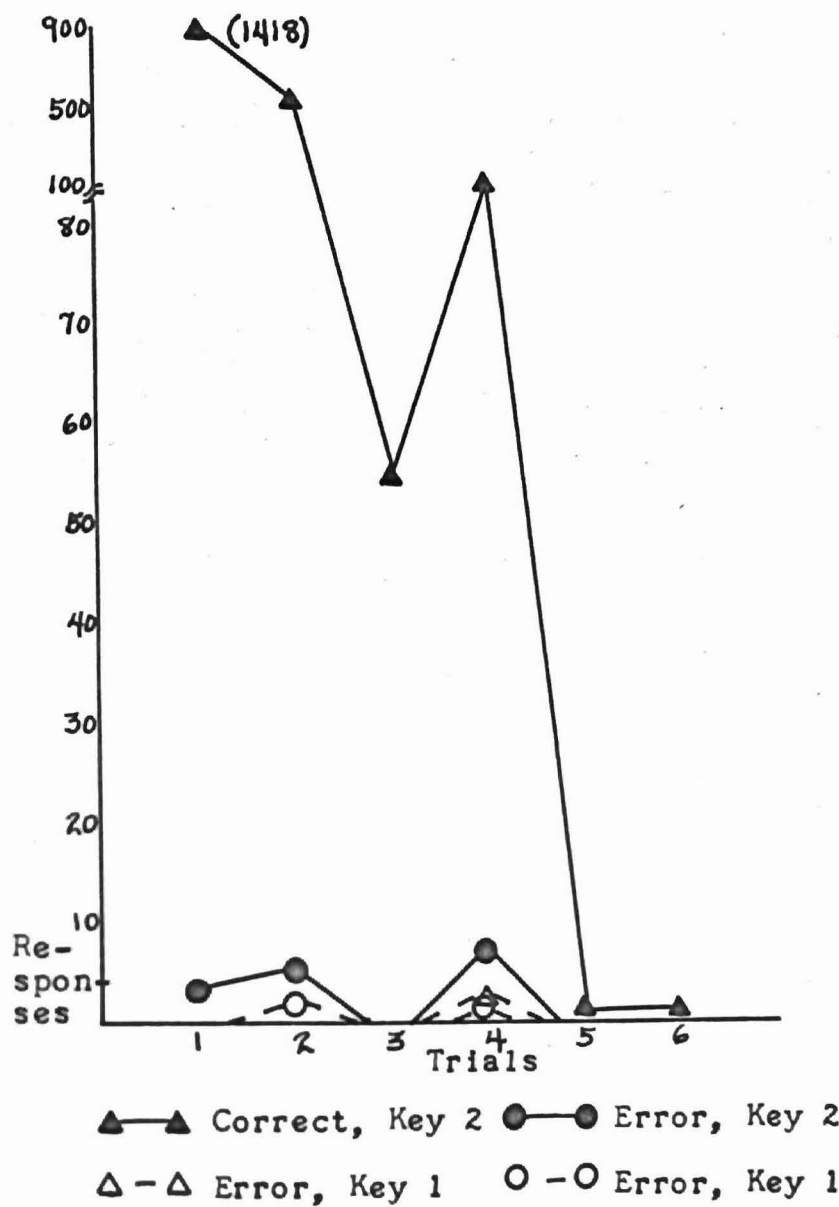


▲-▲ Correct, Key 1 ●-● Error, Key 1
 Δ-Δ Error, Key 2 ○-○ Error, Key 2

Group I - Animal B-3

S_D , S_{δ} Paradigm

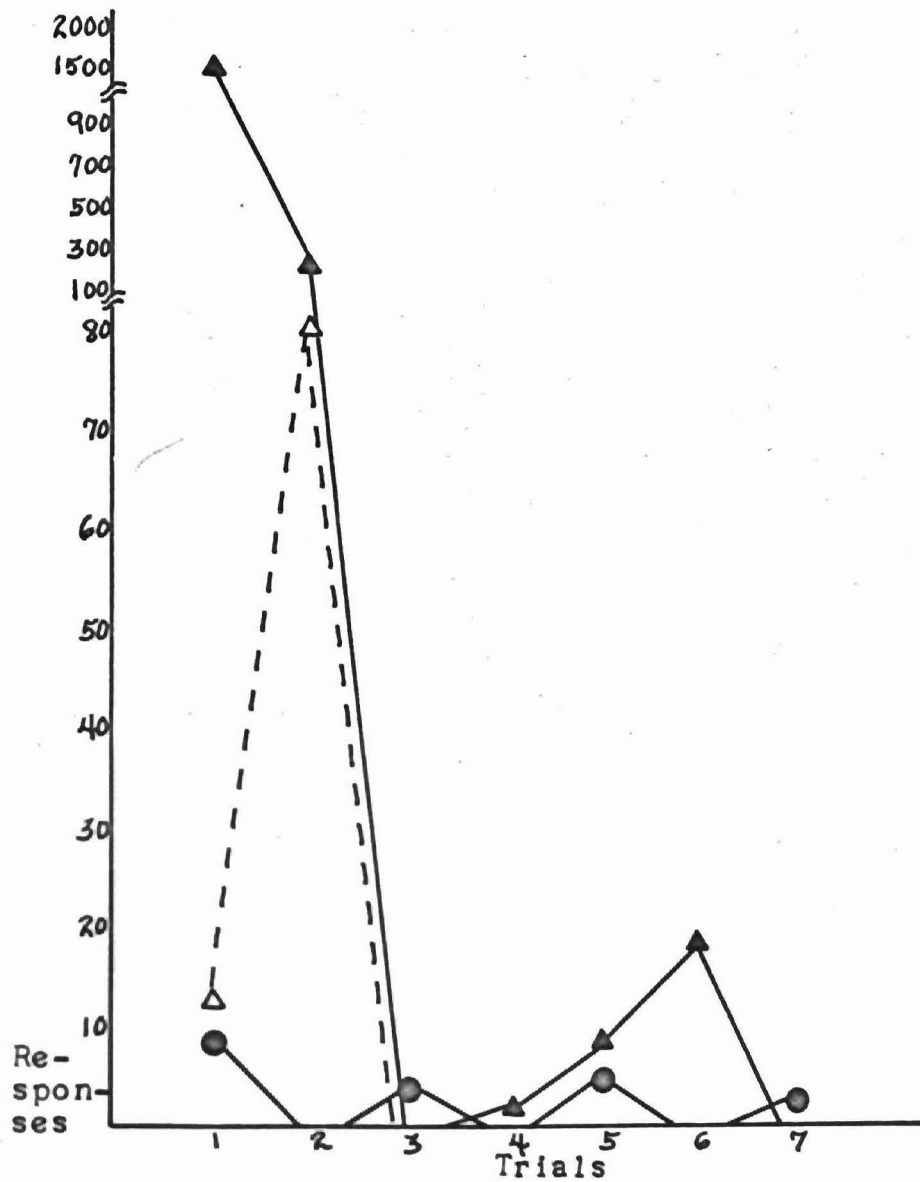
Extinction: 5 Trials



Group I - Animal A-2

S_D , S_{Δ} Paradigm

Extinction: 6 Trials

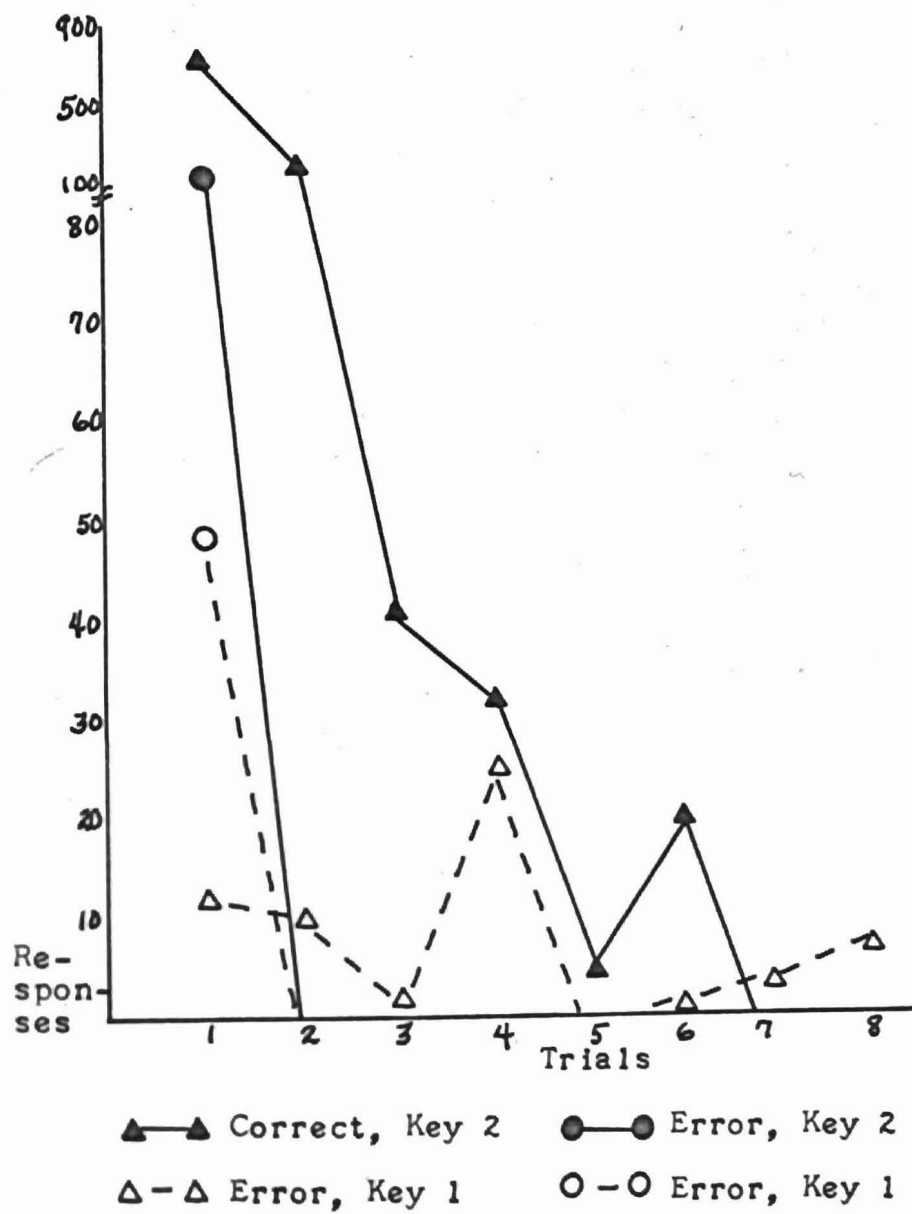


▲—▲ Correct, Key 2 ●—● Error, Key 2
 Δ—Δ Error, Key 1 ○—○ Error, Key 1

Group I - Animal B-2

S_D , S_{δ} Paradigm

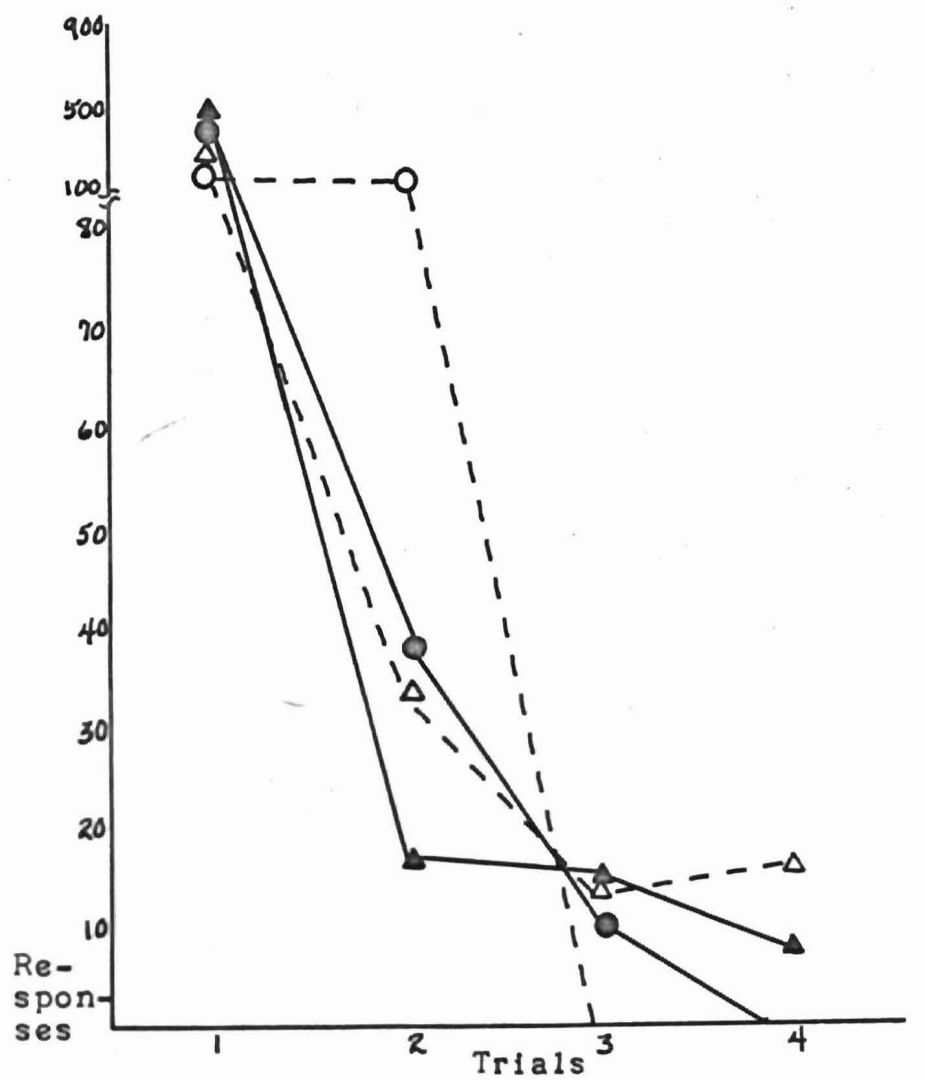
Extinction: 7 Trials



Group I - Animal A-4

S_D , S_{Δ} Paradigm

Extinction: 8 Trials

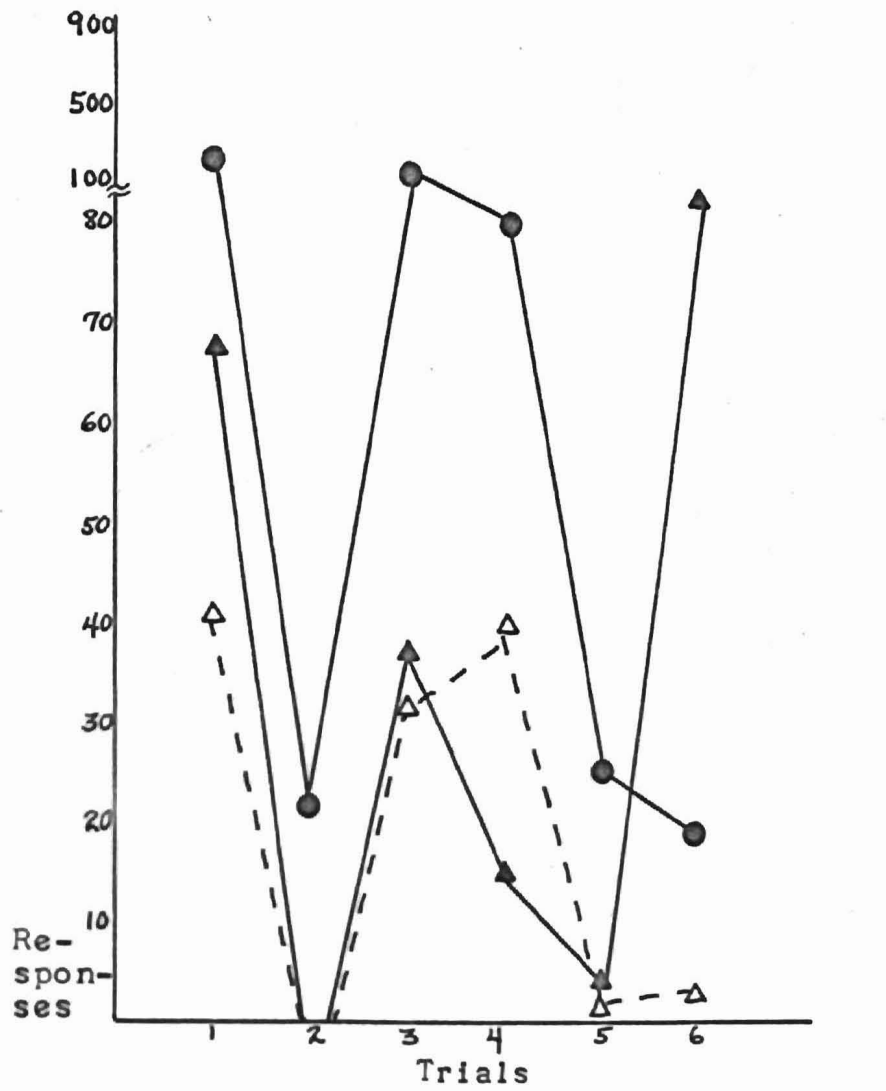


▲—▲ Correct, Key 1 ●—● Correct, Key 2
 △—△ Error, Key 2 ○—○ Error, Key 1

Group II - Animal B-6

S_{D_1} , S_{D_2} Paradigm

Extinction: 4 Trials



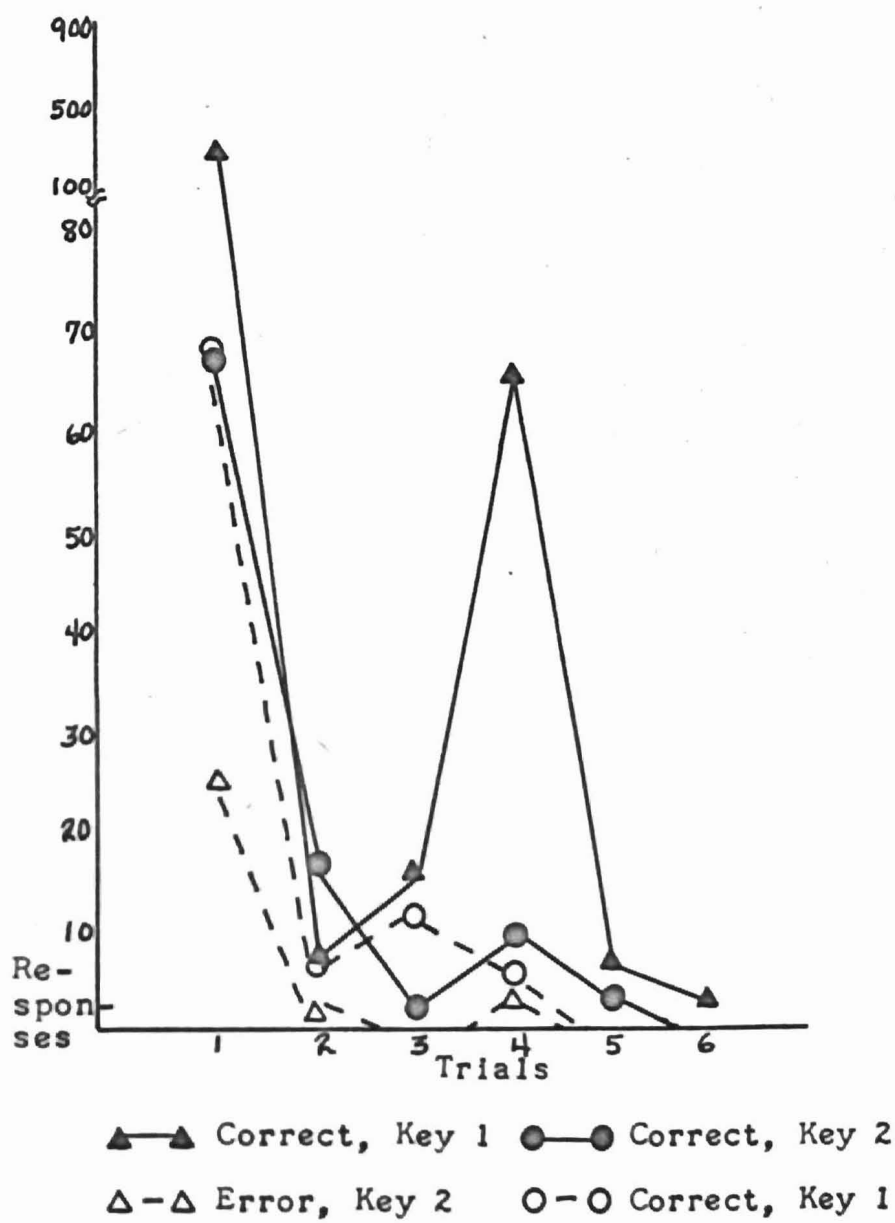
▲—▲ Correct, Key 2 ●—● Correct, Key 1

△—△ Error, Key 1 ○—○ Error, Key 2

Group II - Animal B-4

S_{D_1} , S_{D_2} Paradigm

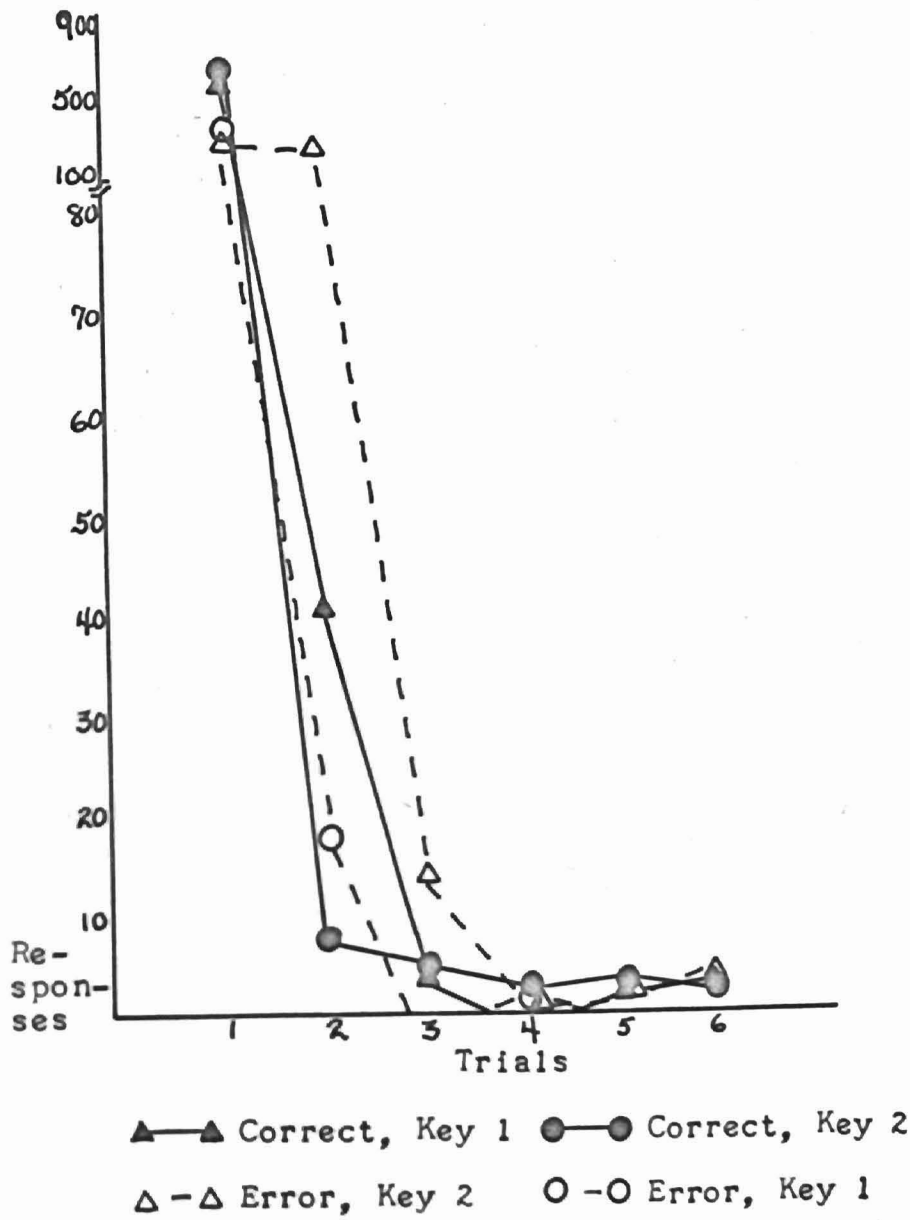
Extinction: 6 Trials



Group II - Animal A-6

S_{D1} , S_{D2} Paradigm

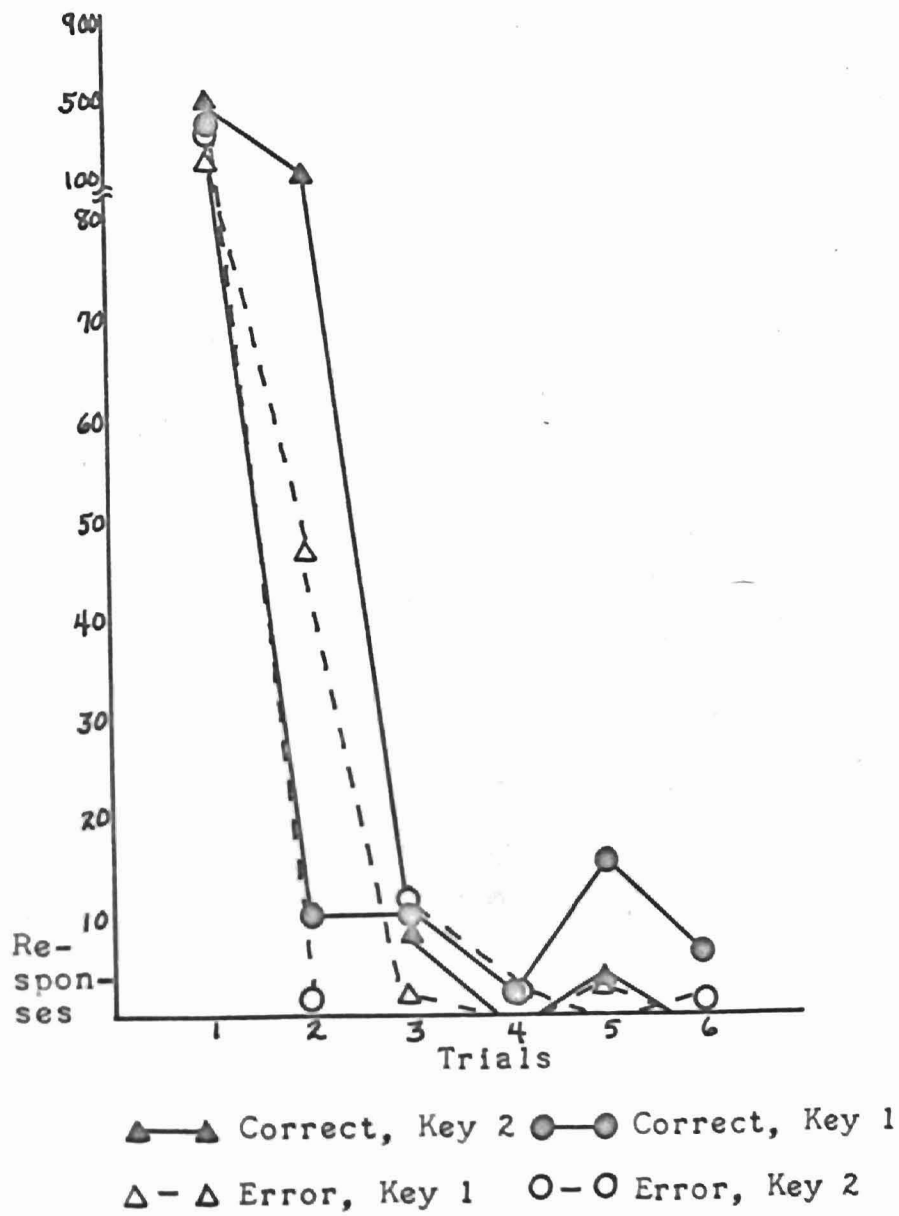
Extinction: 6 Trials



Group II - Animal B-2

S_{D_1} , S_{D_2} Paradigm

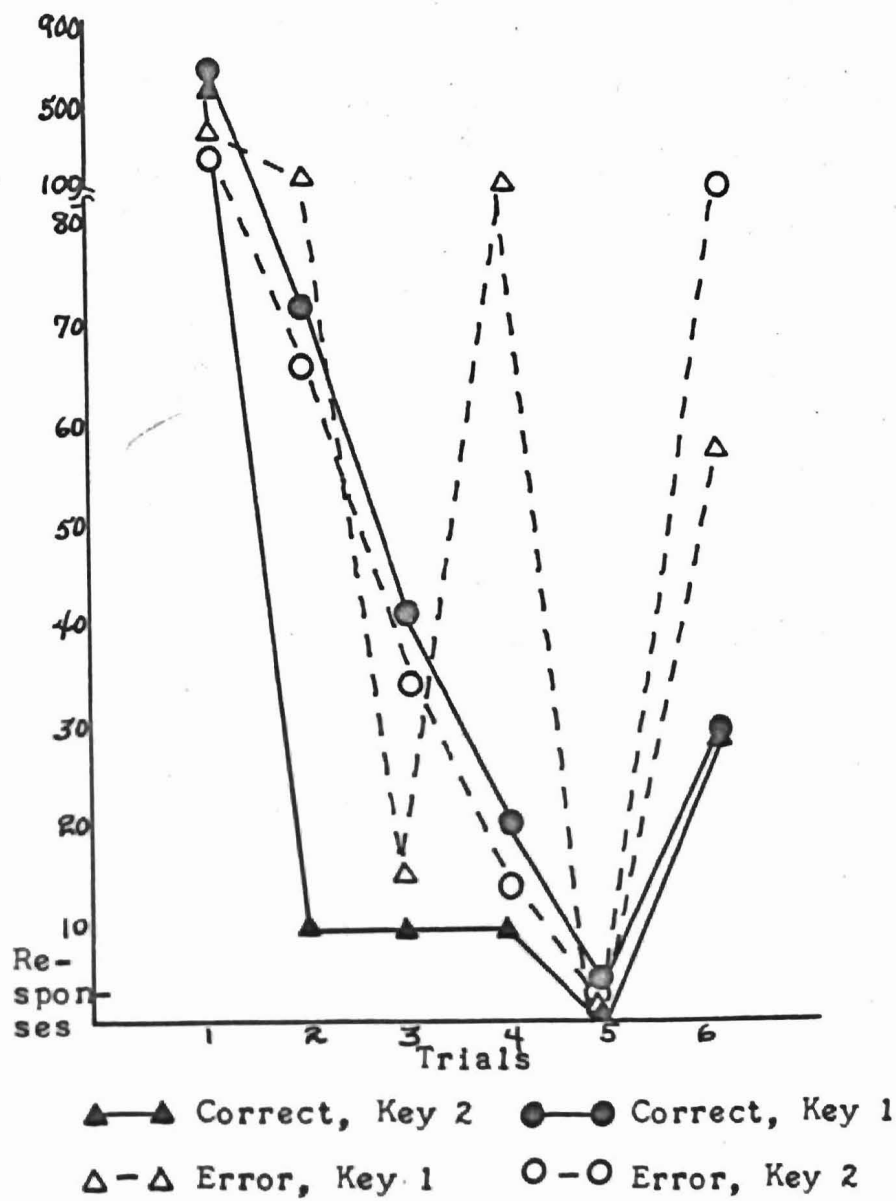
Extinction: 6 Trials



Group II - Animal B-3

SD_1 , SD_2 Paradigm

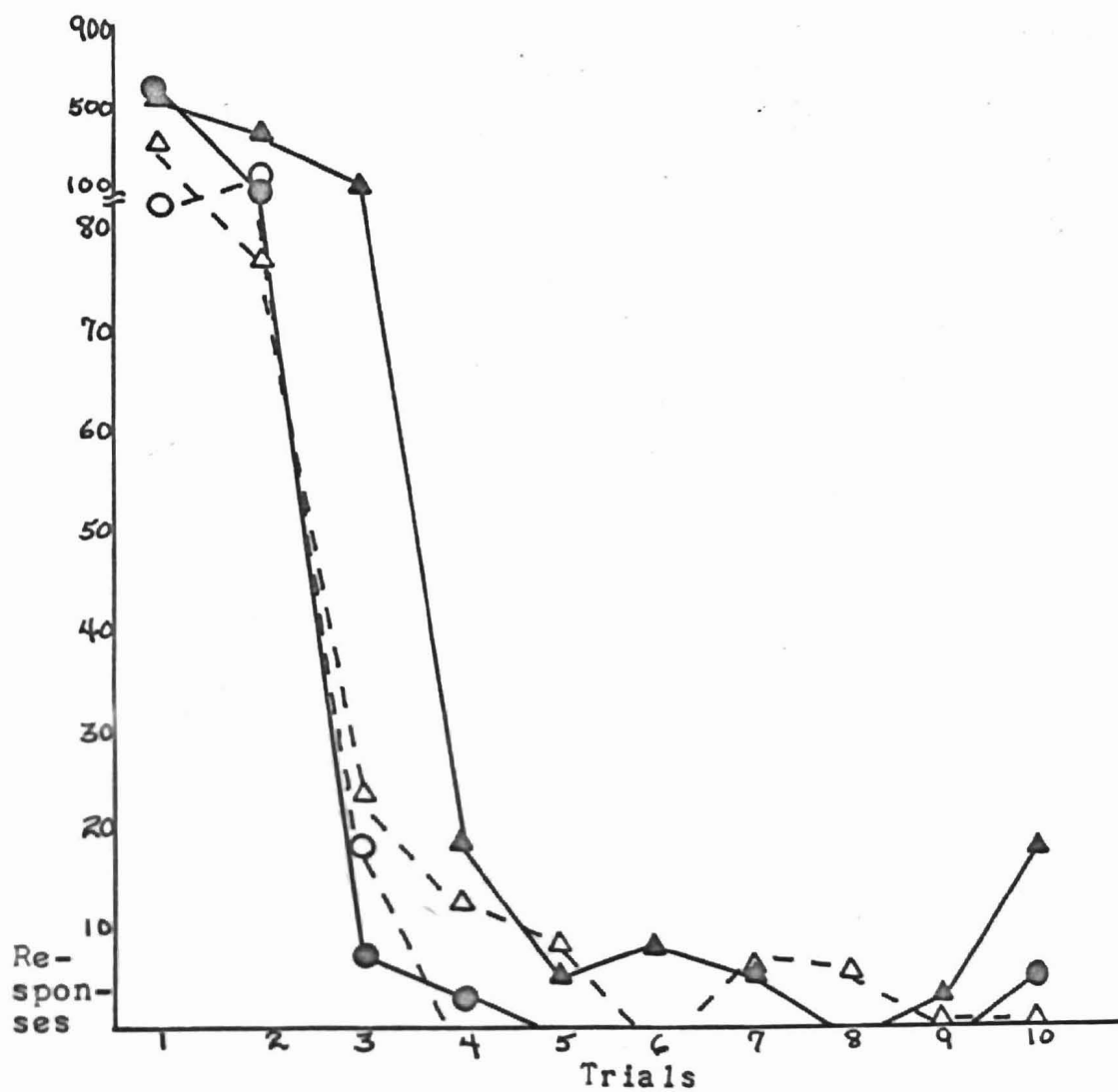
Extinction: 6 Trials



Group II - Animal A-2

S_{D_1} , S_{D_2} Paradigm

Extinction: 6 Trials



▲—▲ Correct, Key 1

●—● Correct, Key 2

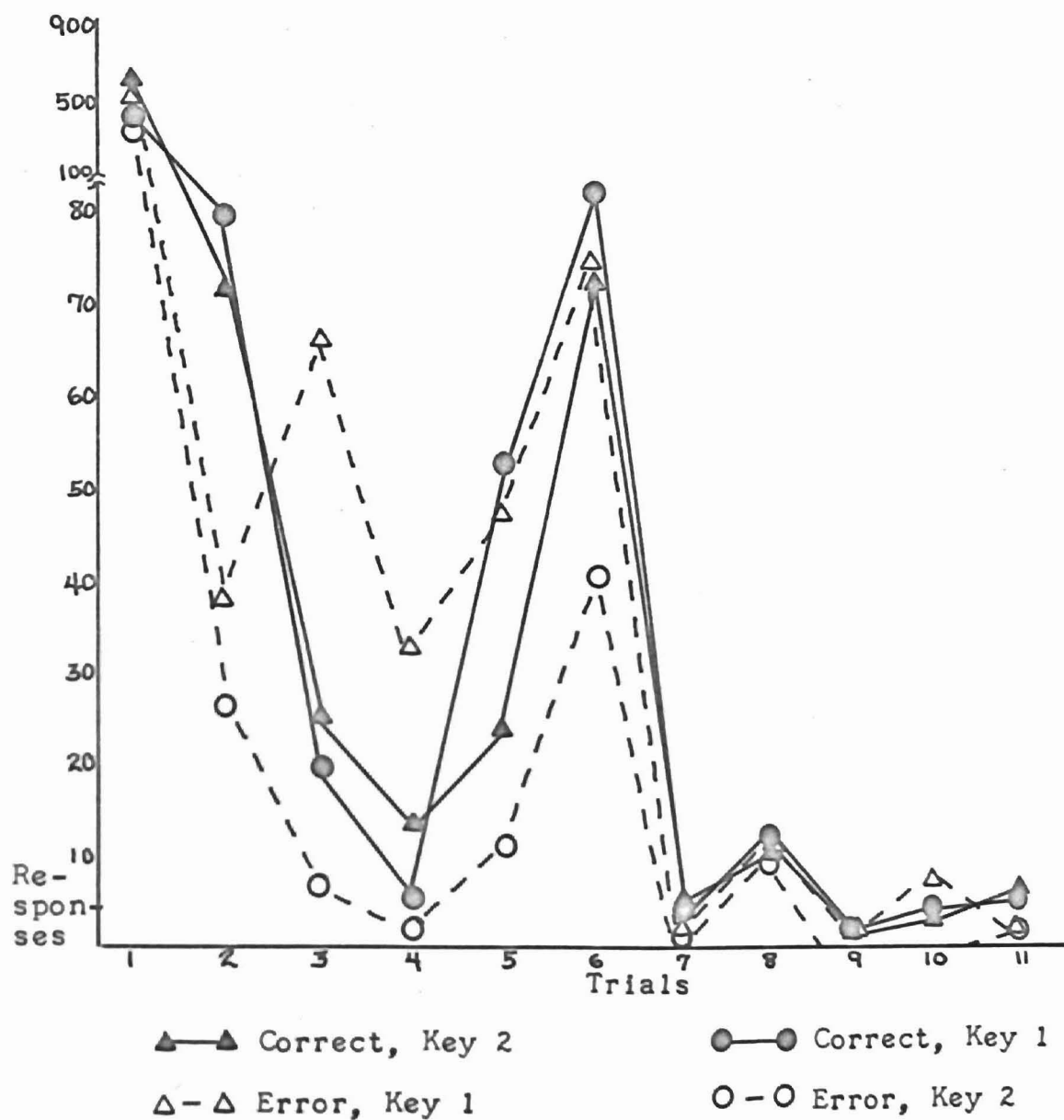
△—△ Error, Key 2

○—○ Error, Key 1

Group II - Animal A-3

S_{D_1} , S_{D_2} Paradigm

Extinction: 10 Trials



Group II - Animal A-4

S_{D_1} , S_{D_2} Paradigm

Extinction: 11 Trials

TRIALS TO ACQUISITION OF DISCRIMINATION

Mann-Whitney U Test

Group I, (C)	N=8	Group II, (E)	N = 8
6		10	
7		11	
7		11	
7		16	
8		17	
9		17	
9		20	
15		32	

APPENDIX C

6	7	7	7	8	9	Statistical Computation					17	17	20	32
C	C	C	C	C	C	C	E	E	E	C	E	E	E	E

U=3**

**Significant at the .002 level.

TRIALS TO ACQUISITION
OF DISCRIMINATION

Mann-Whitney U Test

Group I, N=8
(C)

6
7
7
7
8
9
9
15

Group II, N = 8
(E)

10
11
11
16
17
17
20
32

3 4 4 5 6 6 8 6 8 1 1 1 12 12
6 7 7 7 8 9 9 10 11 11 15 16 17 17 20 32
C C C C C C C E E E C E E E E E

U=3**

U=26, converted to Z score = .43, probability .37

U=26, converted to Z score with continuity correction = .541
probability = .283

**Significant at the .002 level.

PROPERTIES TO EXTINCTION
OF DISCRIMINATION RESPONSE
DURING EXTINCTION

Mann-Whitney U Test
Mann-Whitney U Test

Group I, N=8
Group (C) I, N=8
(C)

7
4.52
6.24
8.72
5.72
3.80
7.84
8.88
.88

Group II, N=8
Group (E) II, N=8
(E)

10
6 .14
6 .66
12 .60
6 .22
6 .24
6 .56
4 .14
.14

3 4 4 5 6 6 6 6 6 6 7 7 8 8 10 12
C C E C C E E E E E C C C C E E

.14 .14 .14 .22 .24 .28 .52 .56 .60 .66 .72 .72 .80 .84 .88 .88
E E E E C E U=26 (probability .574)

U=26, converted to Z score = .630 (probability .528)

U=26, converted to Z score with correction for ties = .641
(probability .528)

**Significant at the .006 level.

PROPORTIONAL DIFFERENCE BETWEEN
CORRECT AND ERROR RESPONSES
DURING EXTINCTION

Mann-Whitney U Test

Group I, N=8
(C)

.52
.24
.72
.72
.80
.84
.88
.88

Group II, N=8
(E)

.14
.66
.60
.22
.28
.56
.14
.14

.14 .14 .14 .22 .24 .28 .52 .56 .60 .66 .72 .72 .80 .84 .88 .88
E E E E C E C E E E C C C C C C

$U' = 57$
 $U = 7^{***}$

***Significant at the .006 level.